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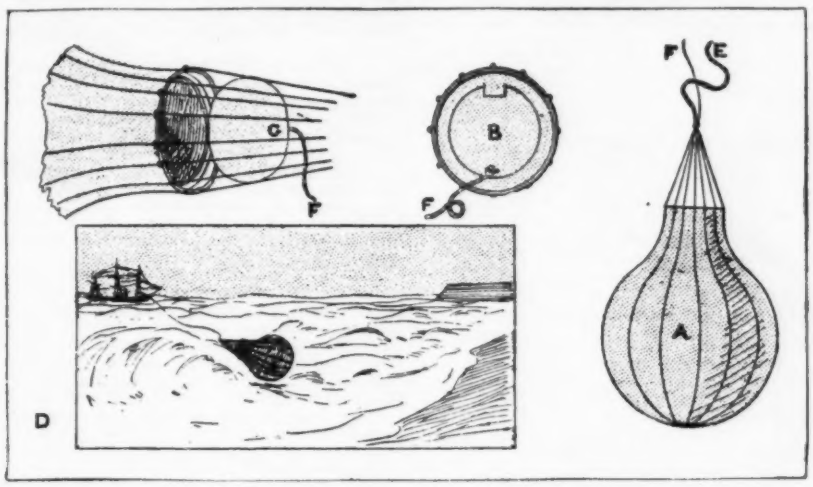
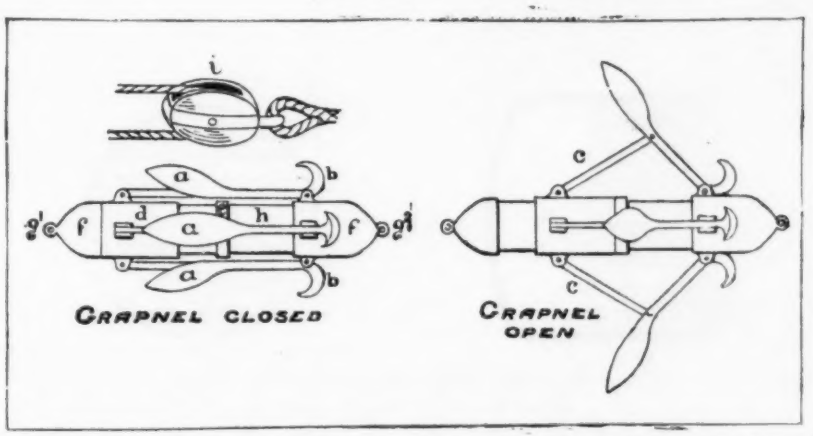
LIFE SAVING DEVICES.*

FROM Mr. Thomas H. J. Pryce comes a suggestion of "A Balloon Life Line Carrier," which is to be made of a strong waterproof material capable of resisting the strain of the wind and waves. Two ropes would be required to work the valve, and the main rope, which would have to be connected with the cords round the balloon. The valve would have to be fitted with a catch, so that when once closed, pressure would not open it. The main rope would be a life line, and the balloon itself, lying high out of the water, would thus be carried rapidly ashore. When required for use, says Mr. Pryce, "let the appliance be taken to the most suitable part of the vessel for fixing, then first let a pulley block be attached to fixing, pass main rope through this, and make fast. Next secure valve rope. After this is done, ease off main rope until valve is open, taking care that the strain is borne by both ropes. The valve, being open, would allow the wind to enter and inflate balloon rapidly. This done, cut away valve rope so that the valve will close and become locked, when the main rope may be paid out, and communication with the shore effected." The references are: A, balloon inflated; B, end showing valve closed; C, end showing valve open; D, balloon in use; E, main rope for attachment to pulley block or grapnel, if used; F, valve rope.

Mr. Pryce also sends a design for a special grapnel for use with the balloon. It is to consist of a hollow tube or cylinder, air-tight, fitted with four movable arms working in concert, those parts corresponding to the flukes of an anchor to be spoon-shaped. At the other end of these arms a small spoon-shaped drag is designed to assist the arms in extending until they are forced open by their grip on sand or rock. The proportions of this apparatus would have to be regulated by the water displacement. The movable collar which would carry the stays for the arms is intended to be similar in action to the arrangements in an umbrella for extending the ribs. When using the grapnel with life line carrier, a pulley block should be attached to the grapnel marked G, the opposite end having been fixed to the balloon after its inflation. The life line in this case would pass through the pulley, one end being attached say to a mast, while the other line would be paid out through the pulley on the ship. As soon as the grapnel is fixed on shore, the two ends of the life line would be joined, so that the rope can circulate freely, and carry ashore or convey from shore as the case might be. The references are: A, spoon-shaped flukes; B, drags to assist extension of fluke arms; C, stays to bear strain; D, collar to which stays are attached so that the movement of one opens all; E, stop for collar; F, caps with rings, G, for attachment; H, hollow metal cylinder or float; I, pulley block to be attached to ring, G.

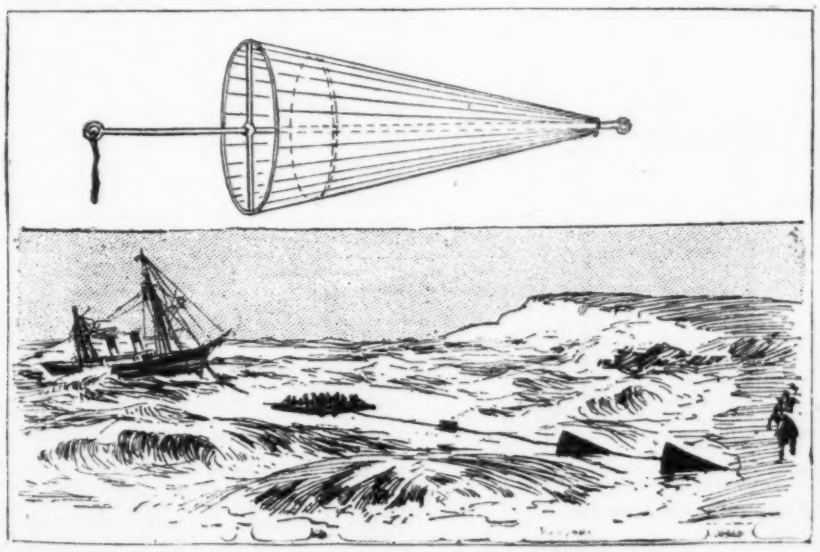


BALLOON LIFE LINE CARRIER. (From a design by Mr. Thomas H. J. Pryce.)



GRAPNEL FOR USE WITH BALLOON. (From a design by Mr. Thomas H. J. Pryce.)

* Continued from SUPPLEMENT, No. 849, page 13561.



NEWELL'S LIFE LINE CARRYING CONE.

Dr. Newell is a physician of New Jersey, U. S. A., and the description of his appliance for communicating between a stranded ship and the shore has been sent us by Mr. D. L. M. Moore. Dr. Newell has, we are informed, been awarded a medal for his design by the American Institute. The invention consists of a cone of metal or any material that can be made to float, which is filled with ground cork up to the dotted ring. It is about 40 inches long, and 24 inches at base, with a waterproof line attached to a rod that projects beyond the base of the cone. This rod acts as a guide or rudder, causing the flange at the base of the cone to catch the wind and waves, and above all to utilize the coast current at an angle, making it the driving power to cross directly to the shore. The more severe, the inventor claims, are the coast current, wind and waves, the more certain and rapid is its work. When on the beach the flange catches in the sand and holds the line fast to the shore. The invention seems to have been tested by Rear-Admiral Braine, of the American navy, acting under instructions from the Secretary of the Navy, when the report was very favorable. It is especially mentioned that the hold of the carrier on the sand beach seemed sufficient to take a life raft ashore. "Six sailors could not haul the anchored carrier off the beach." A sketch is given of the apparatus at work taking a life raft to the beach, and spreading oil on the waters to flatten their crests, but no details of how it is done have reached us.

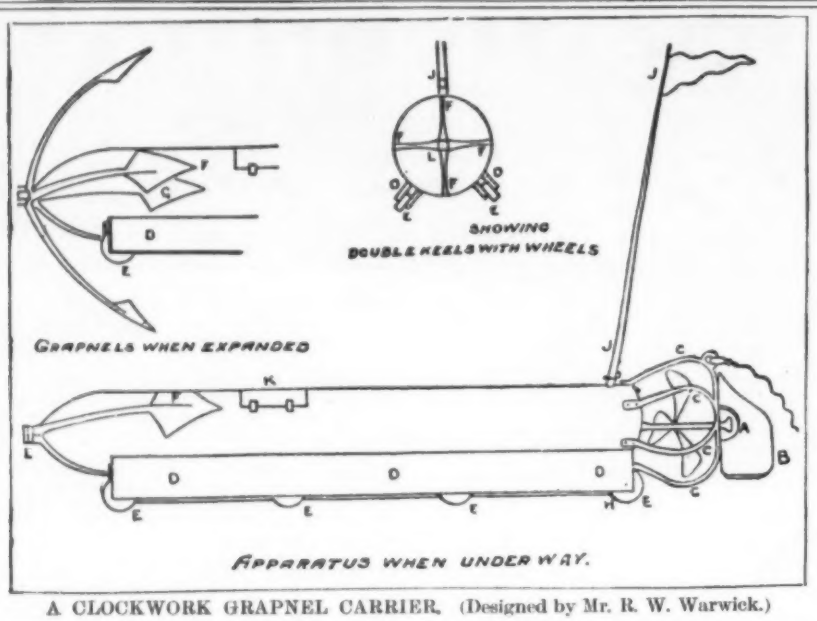
The idea of Mr. Rhys is to establish speaking communication between ship and shore. His design is to transform the ordinary rocket into one carrying a telephone mouthpiece. In the top part of the rocket he would insert a telephone, covered by a cap to protect it from injury. The rocket line is to be an isulated copper wire. The telephone could be either mechanical or magnetic. The notion, of course, is that when a wreck took place the telephone rocket could be sent ashore, and the men on board and the men on shore discuss ways and means. Mr. Rhys says the reason he puts forward this form is that "it is simple and cheap and always ready for use, and any one can understand it."

The sketch of the invention for the purpose of establishing communication between a stranded ship and the shore, designed by Mr. R. W. Warwick, may be called a grapnel carrier, driven by clockwork. Mr. Warwick, in his description, says that it will have to be constructed large enough to contain the necessary amount of air-tight chamber space to insure its floating. The motive power would be the simplest form of clockwork, with a powerful coil spring.

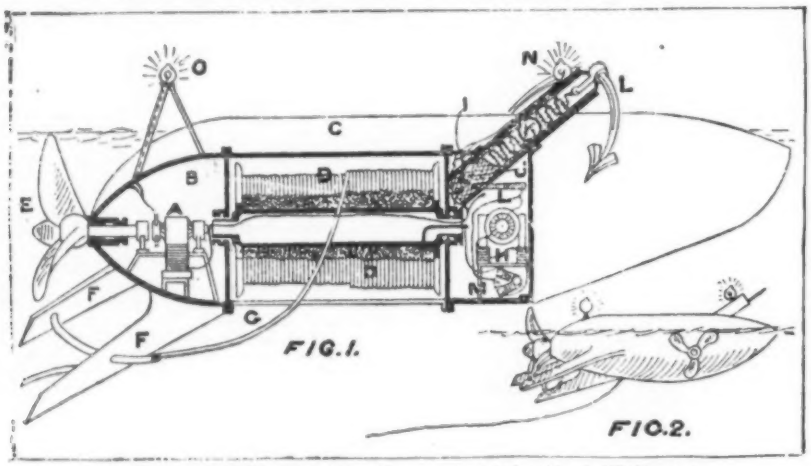
The sketch shows the apparatus as it would appear under way, in section and with grapnels expanded. The spring is wound up by twisting the propeller the reverse way, by means of either a key handle, A, or a winch key. The rudder, B, could be shipped or unshipped by sliding into a square groove at the back of the cage, and is then a fixture. The cage, C, is to prevent the propeller becoming clogged with seaweed, etc. On either side of the bottom would be two double keels, D, which act as ballast, and between the keels would be four or more wheels, E, enabling the apparatus to run itself ashore more easily. In the nose of the apparatus would be four grapnels, F, working on hinges in the center, I, like the ribs of an umbrella,

A ROCKET TELEPHONE.

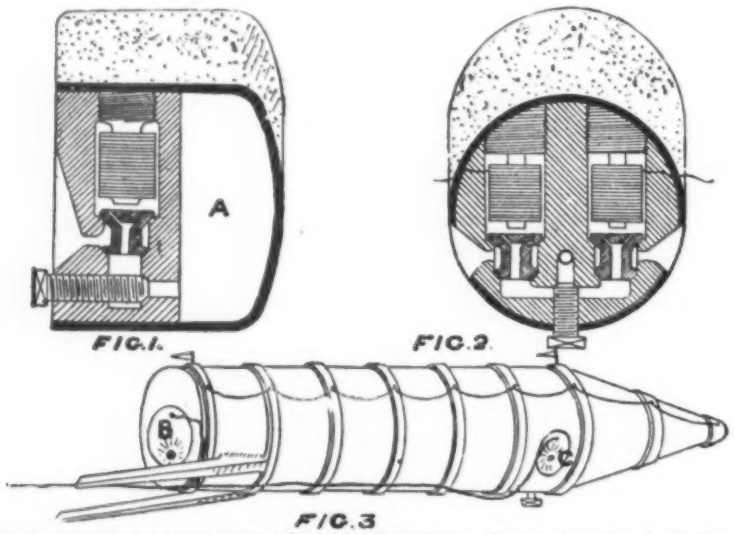
(From a sketch by Mr. F. M. Rhys.)



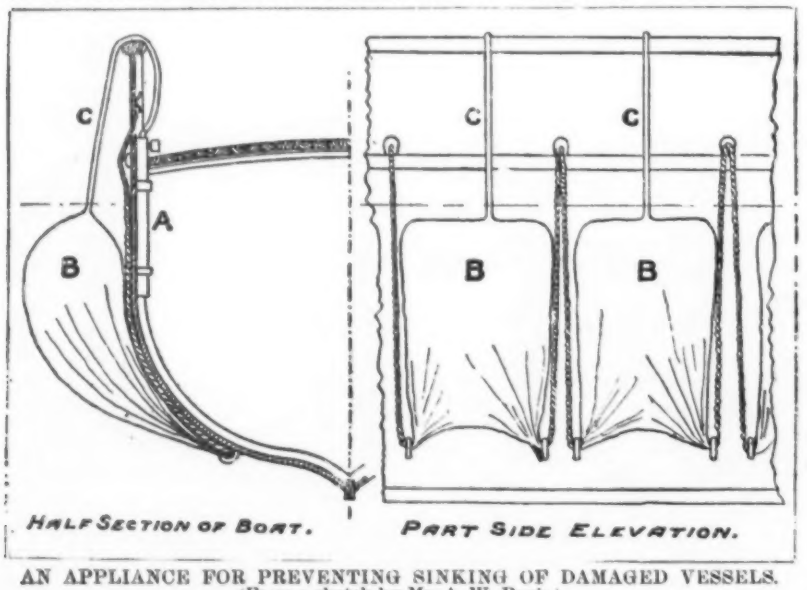
A CLOCKWORK GRAPNEL CARRIER. (Designed by Mr. R. W. Warwick.)



AN ELECTRIC FLOAT. (From a sketch by Mr. A. W. Bevis.)



STEEL TUBE PROPELLED BY ELECTRICITY. (Designed by Mr. A. W. Bevis.)



AN APPLIANCE FOR PREVENTING SINKING OF DAMAGED VESSELS.
(From a sketch by Mr. A. W. Bevis.)

and falling when closed into grooves, G, made for their reception. These grapnels could be made to work automatically, the lower ones opening out by their own weight and collapsing when the machine is under way by the pressure of water upon their broad anchor flukes; or they might be constructed to fly open, a spring being released by a trigger in the bottom of the stern, say at H, upon its touching ground. It would carry a hinged flagstaff, J, and at K could be a water-tight compartment to hold a letter.

Mr. Bevis sends us three suggestions. The first is for the construction of a buoy worked by electricity. Fig. 1 is a section of the float, Fig. 2 a sketch of the float in use. The other references are: A, motor; B, air chamber; C, cork or air chamber; D, drum with a mile and a half of cable; E, propelling screw; F, three projecting horns; G, cable; H, motor for working the two steering screws; I, powder; J, fuse; K, chain; L, drop lever to connect circuit after fuse is fixed; M, automatic cut-offs; N, grappling iron; O, green electric light—a red electric light is also shown at the grappling iron. The buoy is fitted with two small electric motors, one to work the propelling screw, the other the steering screws. In the center of the buoy is a cable which would be dropped as the float proceeded. A rocket in the head of the float would be fired on its reaching a wreck from which the seaman could not reach the float. This rocket is intended to carry a manila line over the vessel.

Mr. Bevis' second design is a steel tube filled with compressed air at about 1,500 lb. to the square inch. The top is to be covered with cork. The propulsion would be effected by the opening and closing of valves worked by electricity either from the ship or from land. The opening of the valve would cause the air to rush out and drive the tube along. Side valves would be provided for steering purposes. In Fig. 1 a section of the propelling valve is shown, with A, compressed air chamber; in Fig. 2 a section of the steering valves; and in Fig. 3 the float itself, with B, air outlet for propelling, and C, air outlet for steering.

The third suggestion has most to do with preventing damaged vessels from sinking and with raising damaged vessels from the ground, and does not apparently comply with the conditions of the competition, although this, of course, is a matter for the decision of the experts. The sketch shows, A, steel tubes of compressed air, 1,500 lb. to the square inch pressure; B, bags filled with air; and C, India rubber tubes:

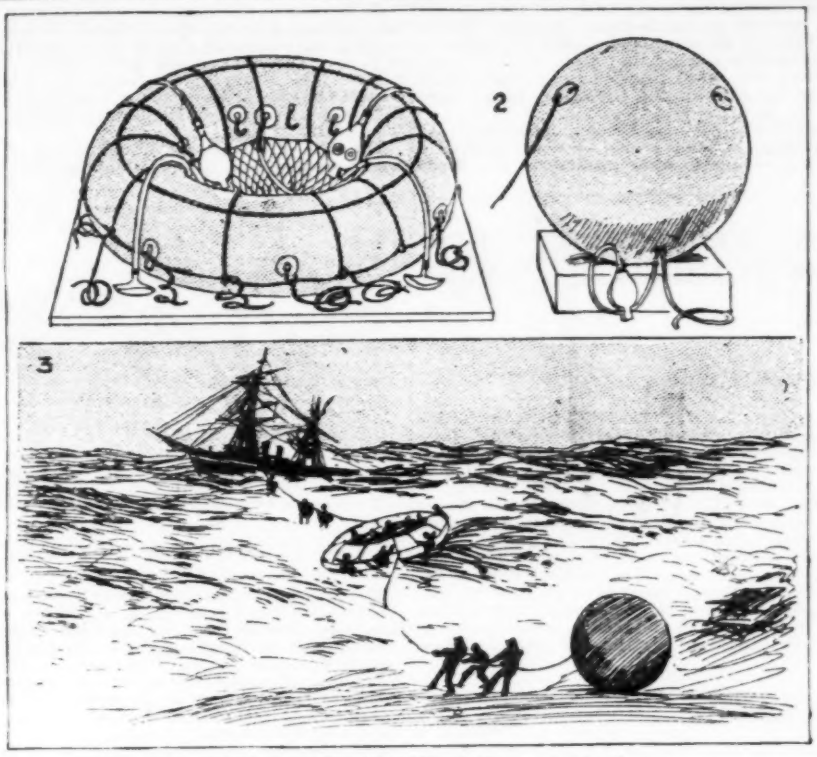
The bags would be made of waterproofing and would be hung from the ship's side, and the India rubber tubes should have a union to fit the steel tubes. "Suppose," says Mr. Bevis, "the vessel has sprung a leak. All hands would have to get these bags out, fix the India rubber tube to the steel tube, attach one end of the rope or chain (which passes through eye bolts) to the net covering, and by means of the other end of the rope pull the bag down to the eye bolt under water and make fast the rope on deck. The screw valves are next opened and the air rushes in to fill the bags. This will raise the boat up perhaps sufficiently to bring the rent above water line."

From Mr. F. Dohn, we have received several drawings of an invention by Aug. Kopcke, of Rotterdam, which has been patented both in this country and abroad. The sketches show both the ball and ring in detail, and the apparatus in use by the crew of a stranded vessel. Both ring and ball are manufactured of the strongest canvas, which, by a special process, is made air and water tight. The ring measures in outer diameter 3½ meters, or about twelve feet, inner diameter two meters, or about seven feet, and is divided into eight compartments, which can, when inflated, be separated from each other by the simple turning of a valve connecting them. The ring is inflated by the aid of four bellows in about 1½ min. (two of them in the sketch have been replaced by fog sirens for use in thick weather), and is provided with a strong netting in the inner space, while numerous cords are attached to the outside in order to enable a person swimming to get into the ring. At the Bremen exhibition fifty persons found ample support, the carrying capacity being about four tons. The actual weight of the ring is only 80 kilos, or about 1½ cwt., and when not in use it is packed in a case about 3 ft. square. The ball, when inflated, has a diameter of about 11 ft., and is intended to establish the communication between the wreck and shore, or two ships after a collision. In the case of a wreck with the wind inshore, the ball is thrown overboard, and, offering its bulky circumference to the wind, it is carried rapidly ashore, bearing a thin strong line. The ring can be used, as in the sketch, to carry the crew ashore.

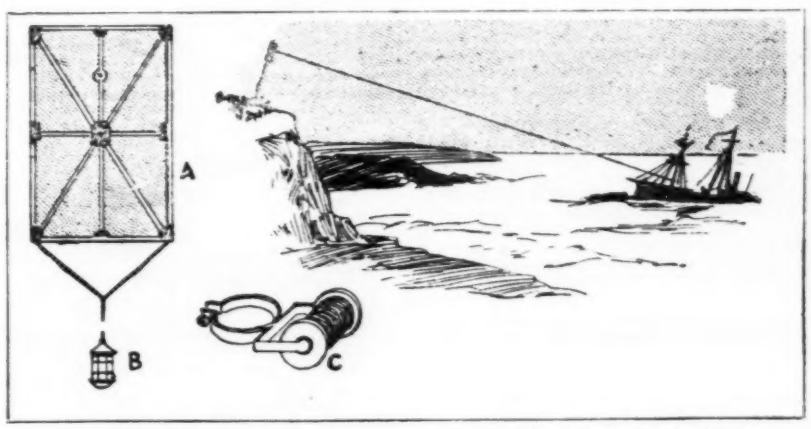
Mr. Marshall says that the suggestion of utilizing the wind itself as a medium for conveying a line from a stranded ship to the shore is "the outcome of a conviction that the rocket as well as the water is too uncertain to be of much practical value in the case of violent weather. The kite, A, say 6 ft. by 4 ft., shows a strong frame of light wood, strengthened at the joints by light metal angles, the body of the kite to be oilskin, so that spray or rain would not materially affect its weight. The outside edge would also have a strong cord in case the wood frame became damaged by wind or water. The tail would have to be properly weighted, and at night a lantern, B, could be placed upon it. Such a kite could carry a cord strong enough to pull a rope on board. A smaller kite than this has, in my own experience, been made to pull a boat up river. The method of bringing the kite to ground would be to let the reel go with the kite before the wind." C shows the reel with adjustment for fixing to mast or spar.

THE LAUNCHING OF THE GOELAND.

WHILE awaiting the realization of the fine and useful project of making Paris a seaport that Mr. Bouquet de la Grye is pursuing with as much talent as conviction, it is interesting to note the progress that the great port of Paris is continually making from the standpoint of both freight carriage and construction. In truth, it depends solely upon our initiative to place the capital of France on a commercial level with the great foreign centers of production and consumption, Saint Petersburg, Amsterdam, Chicago, Manchester, Brussels, etc., and we shall be astonished in the future that questions based upon superannuated arguments have been able, in a country that has created the art



1. The life belt. 2. The life ball. 3. The apparatus in use.
KOPCKE'S APPARATUS.



KITE TO CARRY LINE ASHORE. (From a sketch by Mr. A. Marshall.)

of public works, to retard the solution of a problem which is primordial in its results and secondary in the difficulties of execution.

Paris is already one of the first ports of France, with the prospect of becoming *the* first, and of its commercial place being rendered analogous to that of Anvers. From an inquiry made by the Chamber of Commerce it results that there are at present in Paris 100,000 manufacturers engaged in 308 different industries, employing 416,000 laborers, and doing a business amounting to 3,350 million francs per annum. It is difficult, on reading these figures, not to admit that the cheapest means of transportation is that which puts Paris and the sea in constant communication. So engineers of navigation rightly advise that the present system of river navigation be transformed, and that when circumstances favor it, the heavy and slow barges of inadequate tonnage be abandoned and recourse be had to quick carriages by water.

Our Parisian industry, which is so remarkable for its rapidity of evolution and the adaptation of its means of action to the needs that it clearly perceives, has resolutely embraced this idea. The works of the Société des Anciens Etablissements Cail have undertaken the construction of steam freight vessels, and have shown that Paris is capable of constructing for herself a commercial fleet as well as a flotilla of war when the needs of the moment require it.

Some weeks ago, the Goeland, a screw freight boat of 350 tons, was successfully launched at Saint Denis from the works of the Cail establishments, where it was constructed. This vessel, as well as four similar ones, was ordered from the Cail works by the Compagnie des Transports Rapides de la Seine. It is designed for regular service between Paris and Havre. The following are the principal data:

Length between perpendiculars	148 ft.
Total length	154 "
Breadth	23 "
Depth	10·5 "
Draught, under full load	8·5 "
Burden	350 tons.

The Goeland is provided with a condensing engine of 300 horse power, and is calculated to make seven knots an hour and to be able to tow three 300 ton steel plate barges.

The operation of launching (Figs. 1 and 2) was attended with considerable difficulty, on account of the narrowness of the river and the swiftness of the current at the place. With a slope of one-tenth inch to the foot, the boat, after reaching the water, had no more than about sixty feet to traverse to reach the opposite shore. A pinnace anchored upstream reduced the velocity of the current, a large shield was fixed to the stern to decrease the speed, and powerful hawsers were calculated and arranged to tauten at the proper moment.

The orders for maneuvering were given by drum, in five operations.

The success was complete, and there can be no longer any doubt as to the success of the analogous operations for the little flotilla (which will certainly be followed by others) that is to proceed from the establishment of the Cail society.

This result does genuine honor to Mr. Bourdet, a graduate of the Central School and the distinguished deputy administrator of the Société des Anciens Etablissements Cail, as well as to his assistants, at the head of whom, in this work, must be placed Mr. Dubar, manager of the works of naval construction of Saint Denis.—*Le Genie Civil.*

NEW WHEEL FOR VEHICLES.

THIS is an invention by Parker Merrill, of St. Louis, Mo. The object is to provide a vehicle wheel which

shall have a rigid central portion and an outer elastic or flexible portion constructed with a series of independent springs in such a manner that said springs shall form the outer periphery and tread of the wheel, and shall operate in conjunction with each other, so as to make such tread practically continuous, in which the jolts or jars and constant vibrations of the wheel in passing over rough or stony roads and pavements (as experienced in wheels of ordinary rigid construction) is reduced to a minimum.

We give a side elevation of a vehicle wheel, partly in section, with a portion of the rim broken away, constructed in accordance with this invention.

A represents the hub, B the rim, and C the spokes, which may be assembled in any suitable manner to form the rigid center portion of the wheel.

D represents a series of springs around rim, B, the contour of which approximates that of an epicycloidal curve, which curve is in the direction around the wheel

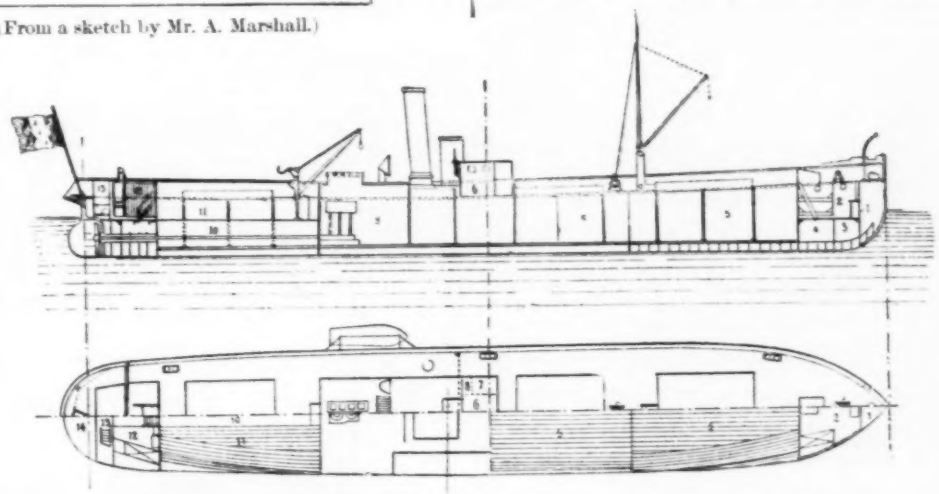


FIG. 1.—LONGITUDINAL SECTION AND PLAN OF THE GOELAND.

1. Bow gallery. 2. Crew's quarters. 3. Chain well. 4. Coal bunkers. 5 and 11. Fore and aft merchandise compartments. 6 and 7. Caboose. 8. Lamp room. 9. Motors. 10. Shaft alley. 12. Captain's cabin on the starboard and chief engineer's cabin on the port side. 13. Water closets. 14. Stern galley.

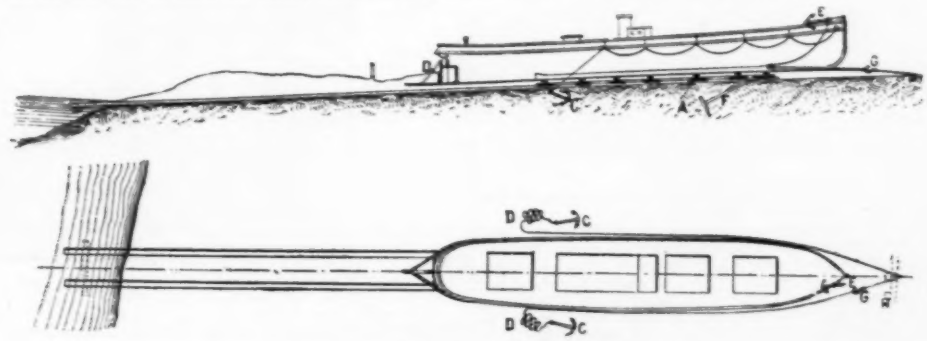


FIG. 2.—LAUNCHING OF THE GOELAND.

A. Ways. B. Resistance shield. C and D. Retaining anchors and cables E. Cradle anchor. F. Dog shores. G. Retaining hooks.

opposite to that in which it is intended to revolve when rolling upon the ground, one end of said spring being rigidly secured to rim, B, while the other end is left free, and forms the outer periphery or tread of the wheel. The rim, B, is preferably formed of sheet steel or other suitable material having an annular channel at its periphery, into which the springs, D, are secured alternately with each other at opposite sides thereof, the channel of said rim being sufficiently wide to allow the free ends of said springs to pass by each other or work side and side without contacting when thus clamped.

The springs are so arranged and shaped that when moving under a load their free ends are sprung in toward the rim and coincide with the true or working periphery of the wheel, and that the springs do not come in contact with the plane upon which they are rolling until the spring is nearly under the center of gravity. Thus it is that the spring resistance is used in sustaining the load and not in retarding the movement of the wheel, and that the springs, after passing the center of gravity, exert a force against the plane over which they are passing to force the wheel ahead, thus making a wheel that is not only easy riding, but easy propelling as well.

A SHORT HISTORY OF BRIDGE BUILDING.*

By C. R. MANNERS.

IN 104 A. D., Trajan erected a remarkable bridge across the Danube. It is mentioned by Pliny, and Dion Cassius gives an account of it. There is a bass-relief representation of this bridge on Trajan's Column at Rome, from which drawings have been made. (See Fig. 30.)

Dion Cassius states that the bridge had twenty piers of square stone, 150 ft. high and 60 ft. wide, and with

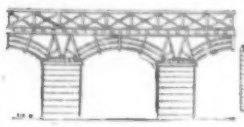


FIG. 30.—TRAJAN'S BRIDGE

FIG. 31.—PALLADIO'S BRIDGE.

openings between of 170 ft. spanned by arches. The arches and whole of the superstructure appear to have been of wood, and it is the first example we have of a timber arch. There is, however, considerable doubt as to Dion Cassius' description, which would make the bridge to be 4,779 ft. long, whereas Conte Marsigli, writing from personal observation, gives the total length as about 3,010 ft. This bridge was destroyed by Hadrian under the pretense that it would facilitate the raids of the barbarians into Roman territories, but the real cause is said to have been jealousy toward the architect, Apollodorus of Damascus, whom he foolishly looked upon as too strong a rival, and whom therefore he put to death. Remains of thirteen of the piers of this bridge are still visible in the river near Washel, in Hungary. We do not find much evidence of timber arches being used in the early centuries. Coming down to the fifteenth century, we find Palladio designed arches somewhat after the style of Trajan's Bridge. (See Fig. 31.)

The bridge over the Limmat, near the Abbey of Wittingen, Fig. 32, erected about the middle of the eighteenth century by John Ulrich Grubenmann, a village carpenter, seems to have been a combination of the arch and truss, and was 390 ft. in span. From this time timber arches seem to have been much in use on the Continent of very considerable spans. In 1794 the bridge of Mellingen, Fig. 33, with a span of 157 ft., was constructed.

In 1801 the bridge of Tournous, over the Saone, with five arches of 89 ft. span. In 1809 the bridge of Bamberg, Fig. 34, over the Regnitz, was constructed by M. Wiebeking, having a span of 206 ft. versed sine of 16 ft. 6 in., and roadway 32 ft. wide. Many others were designed and constructed by M. Wiebeking. The general construction of these timber arches was laminated ribs or planks in layers, curved to the requisite radius and firmly bound together, and this form seems to have been that chiefly used for considerable spans until timber gradually fell into disuse and was superseded by iron.

Perhaps the largest timber arch ever constructed was the one by Louis Wernwag, built in 1813 over the Schuylkill, in Philadelphia, and afterward destroyed by fire in 1838. It was a single arch of 340 ft. span and with a rise of 38 ft.; the breadth of roadway being 30 ft. The principal timbers were of large dimensions, and so placed that the twenty-nine radiating king

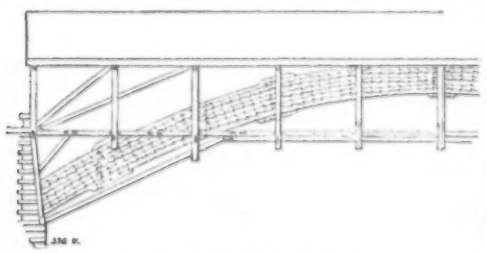


FIG. 32.—BRIDGE OVER THE LIMMAT.

posts were securely fixed without any mortises being cut in the arch timbers. (See Fig. 35.)

To return, however, to bridges of more permanent material than timber. The Romans built many bridges throughout their empire and frequently adorned them with triumphal arches, towers, and such like. Camden mentions a Roman bridge at Duntocher, on the line of the old wall, but I do not think they built many in Britain. Stow says of the bridge built (1100-18) at Bow that "the like had never before been seen in England," which could scarcely have been the case had the Romans built any of a substantial character.

* Continued from SUPPLEMENT, No. 846, page 13560.

We have little evidence of any bridges of consequence in Britain previous to the Norman Conquest. Along the lines of the old Roman roads we find the names of the principal towns ending with "ford," such as Aylesford, Dartford, etc., and I think this goes to prove that bridges did not exist at the times the places were named.

With the fall of the Roman Empire, about 460 A. D., the art of bridge building seems to have received a check, and according to some authorities the Moors

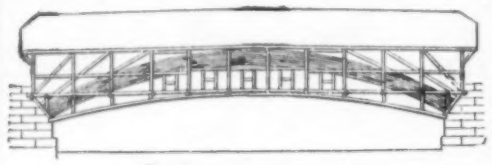


FIG. 33.—BRIDGE OF MELLINGEN.

were the first to revive it in modern Europe, the bridge of Cordova, over the Guadalquiver, being a fine specimen of their work. We read that about the middle of the tenth century Olga, a Russian princess, wishing to improve her country, made walls and built bridges.

During the twelfth and thirteenth centuries the art seems to have been in a flourishing state, as we find many fine stone bridges built about that period.

The monks of these times were the great church and bridge builders. An association was formed called the "Brethren of the Bridge," formed by St. Benezet, who was originally a shepherd, but being frequently warned in dreams to quit his flock and take to bridge building, he obeyed, and apparently with good results. These

FIG. 34.—BRIDGE OF BAMBERG.

brethren spread over Europe, including Britain, building many fine bridges and frequently erecting chapels upon them. One of the earliest was erected at Durance, but sufficient waterway not having been provided, it was soon swept away by floods.

A very bold arch was put across the Serchio, near Lucca, the span of which is 120 ft., with a roadway only 9 ft. wide, and 60 ft. above the water. The date of its erection is given as about 1000 A. D., but this date is very doubtful, and the bridge is more likely to have been the work of the "brethren." Owing to the excellence of the mortar this bridge withstood a flood which rose 30 ft. above the springing of the arch.

In 1178 a bridge was built over the Rhone, at Avignon, and finished in 1188, St. Benezet being the archi-

FIG. 35.—BRIDGE OVER THE SCHUYLKILL.

tect, and in the chapel erected upon this bridge he was buried in 1222. The arch is elliptical, and is, I believe, the first on record for bridge building, and it is further remarkable in that the smaller radius of elevation is at the crown instead of at the haunches. There were 18 arches, the largest being 110 ft. span, with a rise of 46 ft. Four of the arches still remain. The bridge of St. Esprit and of Guillatiere, at Lyons, built in the time of Pope Innocent IV., and others, were the work of the Brethren of the Bridge.

The first arched bridge of stone, erected in England, seems to have been the very singular bridge near Croyland Abbey, in the Fen district. It is supposed to have been built about the year 860 A. D., and is referred to in a charter dated 943 A. D. It is triangular in form. (Fig. 36.) The arches rise from the three

On the southwest wing is a much battered stone figure holding a globe or orb in its hand. This is supposed to be King Ethelbald, though the village lads speak of it as "Oliver Cromwell with a penny loaf in his hand." The object of the bridge is a mystery, as it seems to be quite useless. It has been thought by some to have been erected by the church builders as an emblem of the Trinity.

The style of the present bridge is that of the fourteenth century, and it seems doubtful if it is the erec-

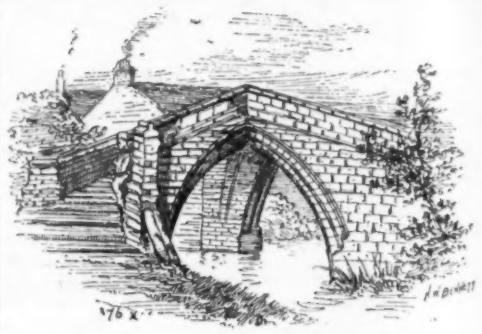


FIG. 36.—BRIDGE NEAR CROYLAND ABBEY.

tion referred to by the charter of 943. One of the earliest stone bridges erected in this country appears to have been over the Lune, at Lancaster, as Simpson, in his antiquities of that town, mentions the ruins of an ancient bridge consisting of two arches, and that when part of the ruins was removed some years ago, some pieces of brass money, supposed to be of the time of Canute, early in the eleventh century, were found under one of the foundation stones.

The first actual road bridge in stone, of which there is authentic record, is that at Stratford, over the River Lea. Many lives were lost in crossing the old ford, and among those who narrowly escaped was Matilda, the Queen Consort of Henry I., who then directed bridges to be built over the branches of the Lea, one at Bow and the other at Channelsea, and connected by a causeway. These bridges were built between 1100 and 1118. Stow says of the bridge at Bow: "The bridge was arched like a bow; a rare piece of work, for before

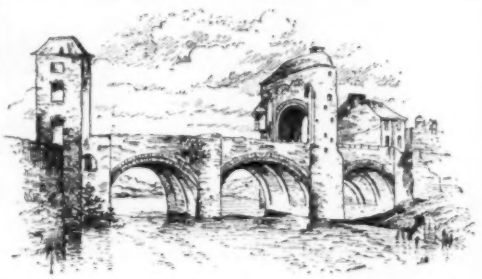


FIG. 38.—MONNON BRIDGE AT MONMOUTH.

that the like had never been seen in England." Tolls were afterward levied to keep them in repair, and among other taxable items, was "for every cart carrying a dead Jew, eightpence." The maintenance of the wooden bridge over the Thames at London, about which I shall give a few notes later on, having become so costly, it was determined to construct one of stone near the site of the wooden one. The work was commenced in 1176 by Peter, the chaplain of St. Mary's, Colechurch. The accounts of the construction of this bridge are very scanty. Stow, and others, have supposed that the course of the river was diverted, through a canal cut in the time of Canute, in order that the foundations of the piers might be laid in the dry bed of the river.

Strong elm piles were driven into the river bed. These

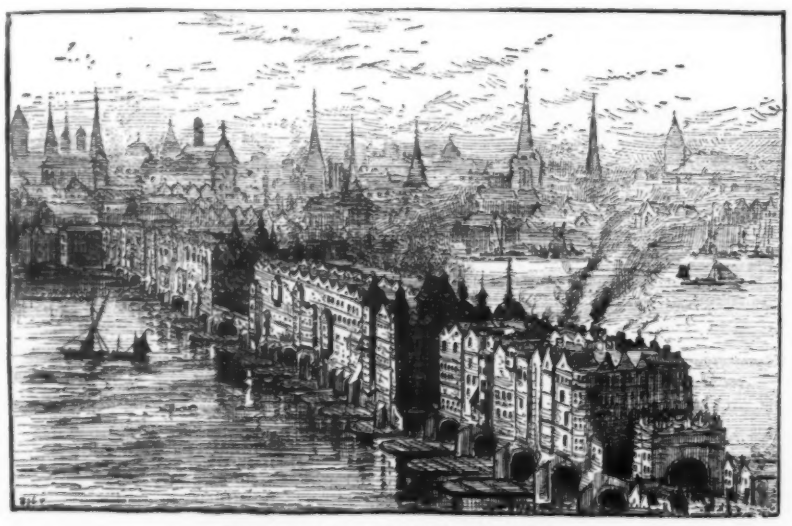


FIG. 37.—OLD LONDON BRIDGE.

abutments and meet in the center, so that there are three waterways below and three roadways above. The ascent is very steep, and to make it easier, steps are introduced. Each pier or abutment was said to stand in a different county, Lincoln, Cambridge, and Northampton.

were deep and close together and over them planks were laid and bolted to the piles. The masonry was built upon this platform, the bottom courses being laid in pitch. Outside all was pile work, filled with rubble and forming great starlings, which greatly contracted the waterway. I may here mention that when new

London Bridge was built, about 650 years after, these elm piles were found in a sound state. The bridge took 33 years to build, and was an unsightly mass of masonry when finished. The piers were thick, the arches small, and both of various sizes. (See Fig. 37.)

The overhanging houses along each side of the roadway, the chapel in the center, and the drawbridge, however, gave it a picturesque appearance.

Its architect died about three years before its completion, and was buried in the crypt, built in the pier under the chapel. So confined was the waterway by the great piers and starlings, and so great the consequent force of the current, that in 1582 it was utilized for pumping up a supply of water for the city. Lives were frequently lost in shooting through the arches, which gave rise to the old proverb that "London Bridge was built for wise men to go over and fools to go under." The bridge and buildings upon it underwent many misfortunes through fire and flood, but by repeated patching it was kept together until 1833.

Other large stone bridges followed the building of London Bridge.

Monnon Bridge, at Monmouth (Fig. 38), as it existed some years ago, was a fine illustration of a fortified bridge. The arches were constructed in ribs and the spans between filled in with masonry.

Bishop Auckland Bridge, over the Wear, built in 1388, is, perhaps, the earliest example in this country of the introduction of the segmental arch.

It has one span of 100 ft. 5 in. and a rise of 22 ft., and another of 91 ft. 5 in., with a rise of 20 ft.

The bridge over the Trent at Burton, by Abbot Bernard, was a good specimen of the art. It was 1,545 ft. long, and had thirty-four arches. One was built in 1295, at Norwich, and one at Rochester, to replace the old wooden one, was built in the time of Richard II.; this being allowed to fall into decay, in 1489 we find John Morton, Archbishop of Canterbury, adopting the extraordinary expedient of publishing a remission from purgatory for forty days and of all manner of fines to such persons as should give anything toward the repairs. The old bridge over the Ouse at York, now removed, was remarkable for the span of its pointed arch (Fig. 39).

Many other bridges were erected and maintained by offerings collected by the priests who ministered in the chantries.

There were many fine old bridges in Scotland, which show that at an early date civilization and prosperity had existed. These bridges were for the most part the work of the churchmen, and when their ecclesiastical organization was destroyed the country lapsed into its

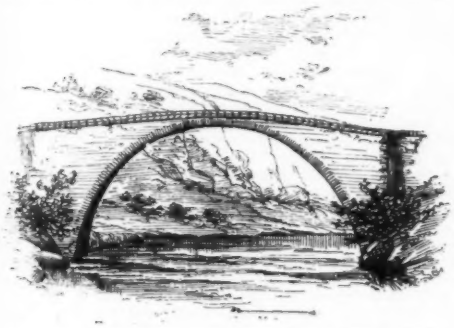


FIG. 40.—BRIDGE OF BRIOUDE, FRANCE.

former state of poverty, from which it was rescued many years afterward, by the influence of education and industry. We find a bridge over the Tay at Perth in the thirteenth century, another over the Esk at Brechin, over the Dee at Kincardine o'Neil, at Aberdeen, over the Clyde at Glasgow, in 1345, and several others.

After these times, however, the art of stone bridge building in Britain seems to have been almost entirely lost, and from the time of Henry VIII. timber constructions appear to have been chiefly used, until about the middle of last century, when the art was again revived.

On the Continent they had not been idle. The bridge of Cret, on the Tech, on the road between Perpignan and Pratz de Mouillon, was built in 1336, and has the very considerable span of 147 ft. 8 in. The arch is semicircular, and this bridge is remarkable for the arches built in the haunches and abutments.

In the latter half of the fourteenth century an arch was built over the Adda at Trezzo, described as "consisting of a single arch of granite, very well constructed of stones in two courses, the innermost 3¼ ft. thick in the direction of the radius and the outermost 9 in., the span at low water 251 ft.," which is, I believe, the largest stone arch yet erected. This bridge was destroyed by Carmagnola.

A peculiar bridge, which still exists, was built over the Ticino, at Pavia, about the end of the fourteenth century. It has seven pointed arches of brick, each 70 ft. span and 64 ft. high. The depth of the arch ring at the crown is 5 ft. 6 in. The tympanum or spandrels are pierced. The roadway is covered by a roof supported upon 100 rough granite columns.

The old bridge of Brioude, across the Olier, in France, was 183 ft. 9 in. span, and had 60 ft. of rise (Fig. 40). Montfaucon and Seguin attribute the work to the Romans, but Gauthey gives the date of its construction as 1454. This bridge fell in 1822.

Then there is the bridge of the Rialto at Venice, begun in 1588, with a span of 91 ft., and many other fine specimens of stone bridges have been built throughout Europe. The time of the first introduction of the oblique or skew arch I do not know, but it appears to have been used in Italy as early as 1530, when Nicolo, called Il Tribolo, built a bridge of this kind over the River Mugnone, near Porta Sangallo, at Florence. Old examples of the skew arch are also to be seen at Cordova, in Spain. It was long after this, however, before the art was sufficiently matured to enable engineers to venture upon oblique arches of any considerable span. In 1756–60 the bridge of Trilport-on-the-Main was built, with elliptical skew arches, the center one 81 ft. and the end ones 76 ft. 9 in. span.

Oblique bridges in stone do not, however, seem to have been much used until after the introduction of railways, and in still later times iron has almost superseded stone for this purpose.

The "Brothers of the Bridge" seem to have been more careful as to securing good foundations than the bridge builders of a later date, for while many of the works of the "Brothers" continue to stand, the more recent ones were frequently swept away by floods, and indeed it is no wonder, for their method of getting in foundations was to throw loose stones promiscuously into the bed of the river, and when they had found their bearings, the stonework of the starlings was built on them.

The second stone bridge over the Thames was not built until 1738–50. This was Westminster Bridge, Fig. 41, and so low was the engineering profession in England at the time, that Thomas Labelye, a French engineer, but a Swiss by birth, was called in as engineer. The first design for a bridge at this place was for a wooden structure, and part of the work was actually contracted for.

Labelye's method of obtaining a sure foundation was an improvement on that above described, but was far from good. He first dredged away the soft mud. A number of caissons, or large water-tight chests, were then prepared on shore; these were floated to the site of the piers and permanently sunk.

The masonry was built up in these caissons, and when above water mark, the sides were removed, and the piers left standing on what had been the bottom grating. Sheet piling was then driven in side by side, as a protection against scour.

Mr. F. Wishaw, in his paper upon this bridge, says that this was the first instance of the application of caissons for the purpose of laying the foundations

FIG. 39.—BRIDGE OVER THE OUSE AT YORK.

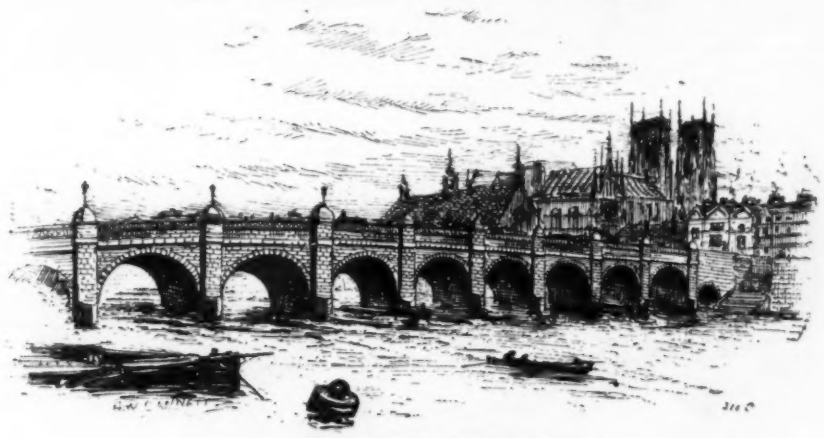


FIG. 41.—OLD WESTMINSTER BRIDGE.

FIG. 42.—OLD BLACKFRIARS BRIDGE.

FIG. 43.—BRIDGE OVER THE TAFF.

under water; but I find Cresy states that at the building of the bridge of the Tulleries, designed by Mansard, and commenced in 1685, Frere Romain, who was called in to carry out the work, made use of a dredging machine to prepare the bed, then sunk a large barge filled with stones, surrounding it with piles and a jetty, and that a kind of chest was then sunk containing courses of stones cramped together.

The piles at Westminster Bridge were driven by an engine invented by Mr. Valone, a watchmaker. It was erected on a platform fixed to the top of a barge, the stone bridge at Westminster has been replaced by a handsome cast iron bridge of seven arches, designed by Mr. Page.

Blackfriars Bridge soon followed (1760–69), the engineer being Mr. Mylne. This bridge is, I believe, one of the earliest introductions into this country of the elliptical arch. Like Westminster, this structure failed through scour of the river bed, and was replaced in 1864–69 by a fine bridge of five spans by Mr. Cubitt (see Fig. 42).

One of the early bridge builders in this country was

FIG. 44.—THE COLDSTREAM BRIDGE, PERTH.

FIG. 45.—WATERLOO BRIDGE.

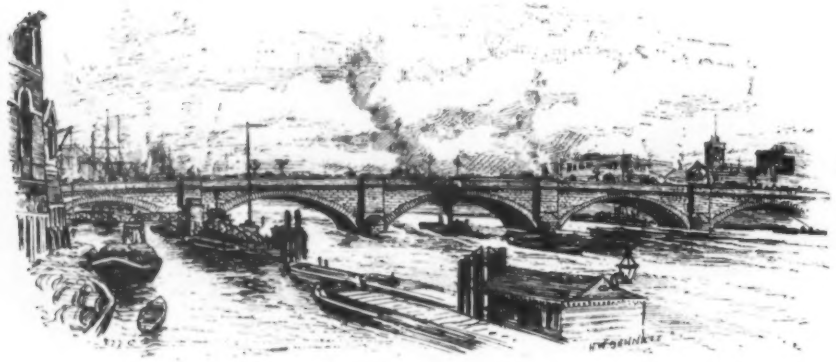


FIG. 46.—LONDON BRIDGE.

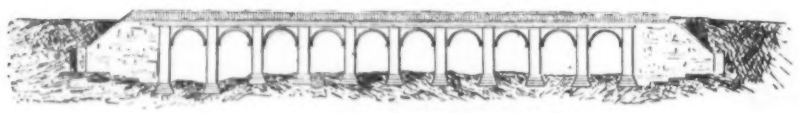


FIG. 47.—THE CHIRK AQUEDUCT.

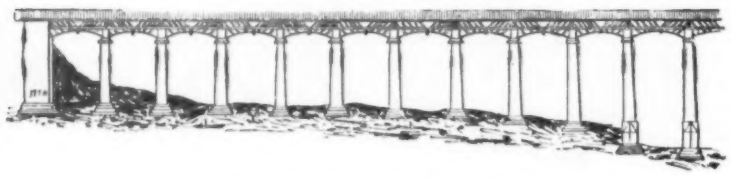


FIG. 48.—PONT CYSYLLTAN AQUEDUCT.

FIG. 49.—BRIDGE OVER THE CLYDE AT GLASGOW.

and worked by three horses walking round and turning an upright shaft on which was fixed a large cog wheel and drum. The number of strokes was about 150 per hour, the elevation 9 ft., and the weight of ram 1,700 lb. This bridge was about 1,223 ft. long and 44 ft. wide, and had thirteen semicircular arches varying from 76 ft. span at the center, and descending by 4 ft. from the center to the sixth arch on each side, which are 52 ft. spans.

From about this time the bridges were so built that the rise of roadway along them was much reduced. The scour of the river soon began to tell its tale, and William Edwards, who commenced life as a dry stone mason or diker. In 1746, when only twenty-seven years of age, he was employed to build a bridge over the Taff in Glamorganshire. His first attempt was a bridge of three spans, which was swept away 2½ years afterward by a flood. He next tried a bridge of one span of 140 ft. He succeeded in finishing the arch, but before the parapets were added, the great pressure on the haunches forced the light crown to spring up, and a second time his bridge was in ruins. He tried again and this time was successful, having introduced three cylindrical holes through each haunch, a plan in use by Continental engineers as early as 1336, and so relieved the haunches of a great weight. This bridge was finished in 1755 (see Fig. 43).

The first aqueduct bridge built in Britain was Barton Bridge, on the Bridgewater Canal, about 1760, by Brindley. This bridge is over the Irwell and has three arches, the center one being 63 ft. span. So wild was the idea thought to be of carrying a canal over a large bridge, that the Duke of Bridgewater submitted Brindley's plans to another engineer, thought to be Smeaton, and his report concluded thus: "I have often heard of 'castles in the air,' but never before saw where any of them were to be erected."

Brindley had a way of his own of illustrating and explaining his designs when giving evidence before a committee of the House of Commons. On one occasion when asked to produce a plan of a proposed bridge, he replied, he had no plan on paper, but would illustrate it by a model. He went out, bought a large cheese, which he brought back to the room with him, cut it in two, saying: "Here is my model." The two halves, set upon the cut side, represented the arches, and by laying over these a long rectangular object he illustrated the position of the canal above and the river below. Time will not permit of further reference to Brindley's works, nor can I do more than mention Smeaton's bridges at Perth, Coldstream, Banff, and other places. Smeaton always adopted segmental or elliptical arches in preference to semicircular, and at Perth Bridge, completed in 1772, Fig. 44, he used cofferdams to enable him to get the foundations down to the solid.

The mail coach system was improved about the year 1784, and between that date and 1792 no fewer than 302 acts were passed for the construction of roads and bridges. This must have given a great spurt to the art of bridge building.

Rennie was, perhaps, one of the greatest and best builders of stone bridges. He had a great regard for theory, and would have nothing to do with mere guess work, which had hitherto been too much the practice. He paid great attention to securing deep and solid foundations, by means of cofferdams.

In 1793 he built a noble aqueduct of five arches of 75 ft. span across the Lune, near Lancaster. To his skill we owe many fine bridges in Scotland, such as the one across the Tweed at Kelso, and over the Esk at Musselburgh, built about 1799, and which seems the model of his future Waterloo Bridge. These bridges have level roadways, a comparatively new feature in stone bridges. His greatest works, however, were in London, where he built Waterloo Bridge, a noble work, opened in 1817. This bridge, Fig. 45, has nine elliptical arches of 120 ft. span and 35 ft. rise. This was, I believe, the first instance of the employment of cofferdams in great tidal waters. The centering was constructed and put together on shore, and floated into position between the piers. His last and greatest design was new London Bridge, which, however, he did not live to see completed. The old bridge had gone from bad to worse, and was a great obstacle to all river traffic, and was at last condemned as a standing disgrace to the capital.

It had for a long time cost an average of £3,500 a year in repairs, so that it was rather an expensive object to keep up. In 1821 an act was obtained to build a new bridge, and Rennie prepared his design, which consisted of five elliptical arches, the center one 150 ft. span, two of 140 ft., and two of 130 ft. span. Rennie died soon after the act was obtained, and it was left for his son, the late Sir John, to carry on the work, which was commenced in 1824 and the bridge opened in 1831 at a cost with approaches of about 1½ millions. This bridge is considered one of the noblest stone bridges in the world (Fig. 46).

I must now make a few remarks as to some of Telford's works, and of these I must mention the Chirk, Fig. 47, and Pont Cysyllтan, Fig. 48, aqueduct bridges. The former is 600 ft. long and was completed about 1802. It is remarkable as being the first instance where cast-iron plates were used to form the bottom of the canal, clay puddle having previously been employed.

The second one crosses the Dee in the vale of Llangollen, and has nineteen arches extending for a length of 1,007 ft., the piers being 121 ft. high. The superstructure is entirely of cast-iron plates, fitted and bolted together to form a trough, and supported on cast-iron ribs, a new departure from all former practice. Telford was also the first to introduce cast-iron turn bridges on his canals, instead of the old drawbridges, and if not the first, he was very near it, to introduce into this country the skew arch. This he did about the year 1824 on the Birmingham Canal. His bridges in stone are very numerous and many of them excellent structures, both in England and Scotland. That over the Clyde at Glasgow, Fig. 49, is a good example.

In 1852–59 a splendid stone arch of 220 ft. span with rise of 57 ft. 3 in. was built on the Washington aqueduct, called the Cabin John Creek Bridge.

This bridge is second only in span to the one over the Adda, already referred to, and is, I believe, the longest span for a stone arch now standing.* The largest span stone arch in this country is the Grosvenor Bridge over the River Dee, at Chester, having a span of 200 ft. and versed sine of 42 ft.

The Ballochmyle viaduct on the Glasgow and Southwestern Railway follows closely, having a span of 180 ft., and is perhaps the widest span stone arch yet erected for carrying a railway.

(To be continued.)

THE CYANIDE PROCESS FOR GOLD.

IN order to understand the present systems of gold extraction, to properly appreciate the work already done, and to gauge the difficulties to be surmounted, it is necessary for us to look back and trace the connection between the known forms of gold as found in nature and the methods used to separate it from its base environments.

In the earliest ages gold would naturally only be found in nuggets and grains (our word carat is derived from a Persian word meaning a grain), which required no means of separation beyond picking up—happy age when gold had only to be picked up!

From grains the ancient would come down to gold dust, and this was no doubt separated from the sand or earthy matter with which it was associated, by the skillful use of air currents which were caused to blow

* See *Engineering*, vol. xlv., page 208.

away the sand, leaving the precious metallic dust. This method is still practiced in Arabia and the East. Wherever water was plentiful it was found that it did the required separation better and more economically than air, a method of separation which has been and still is in use everywhere all over the world. The prospector, digger, explorer, and even the tourist nowadays provides himself with a "pan" in which to wash a sample of "dirt" at the nearest stream. From the pan comes the "cradle," "long tom," and the innumerable mechanical arrangements for the separation of gold from earthy matters. Up to this point we have only mechanical means of separation, which depend on the high specific gravity of gold compared with sand, clay, etc., but at this stage in the evolution of gold extraction we find the first move made toward a chemical method. When there was a lot of rich dirt in his pan the digger found it very difficult to wash away the last of the sand without losing a large proportion of the finely divided gold. So he hit on the expedient of pouring in a little mercury, which formed a heavy, massive, though fluid alloy with the gold, making the separation of the last portions of the light, granular sand a very easy matter. This plan is still in world-wide use alike by the solitary digger who lives in a lonely canyon and by the well organized company that "hydraulics" 1,000 tons of "pay dirt" per day. Let us now look at the present state of the gold industry.

Let us imagine a digger who has exhausted all the gravel and pay dirt in the canyon or gully; he travels up the gulley looking to the right hand and to the left for traces of the precious metal; occasionally he finds a piece of gold-bearing rock and is led on and on till he finds the source of these auriferous stones to be a reef. Now begins gold mining proper.

A shaft is sunk on the reef or a tunnel driven into it and great masses of rock are brought to the surface, and naturally the miner is led to imitate nature by crushing this rock to a fine sand, and then he modifies the treatment, formerly given to alluvial deposits, to adapt it to the new circumstances. The ore immediately on being crushed to powder (which is generally done by huge gravitation stamps) is carried over an amalgamated copper plate by a stream of water. In passing over the amalgamated plate the gold is caught by the mercury, while the sand, now called tailings, is washed off. The gold is recovered by scraping the amalgam off the copper plate at stated intervals, generally once a month, when by distillation the mercury is recovered as well as the gold separated. If all the gold the ore contained existed in the heavy metallic form, the recovery by this method would be complete and the loss *nil;* but the tailings are frequently found to contain a little gold, and on close examination particles of pyrites and sulphides of the various base metals are found diffused through the mass. When these metalliferous particles are separated from the mass of tailings, it is found that they principally contain the gold, so that it is now usual in practice to pass the tailings through some form of concentrating machinery, of which the well-known Frue vanner is a good example, whereby the pyrites and other sulphides are retained in virtue of their higher specific gravity and the sand washed away.

The rich proportion now called "concentrates" may contain up to twenty ounces of gold per ton, though four or five ounces is much nearer the average figure.

If the concentrates are examined closely, even microscopically, no free gold can be distinguished, and if they be treated with mercury, they will yield to it little or none of their gold contents. Sometimes a considerable portion of gold may be got from them by a long-continued grinding in cast iron pans in presence of mercury. This grinding seems to force the sulphur and base metals, as well as the gold, into combination with the mercury, so that the bullion got from the amalgam often contains over 95 per cent. of copper, lead and other base metals, while there is a corresponding loss of mercury which is carried away partly as sulphide and partly in a "floured state." The flouring is caused by the small globules of mercury being coated with a film of sulphide of mercury, which prevents the particles coalescing. Thus there is a double loss—chemical, by the formation of the sulphide of mercury, and mechanical, by flouring. This loss is so well known that concentrates are only treated by this form of amalgamation in localities where nature forbids any more elaborate process. Sometimes the amount of loss may be lessened by roasting the concentrates before amalgamation, but this is by no means a perfect remedy, as the roasting removes only volatile constituents of the concentrates, principally sulphur, while the base metals, lead, zinc, etc., are left in the form of oxide to oxidize and waste their equivalent of mercury. Attempts have also been made to decrease the loss of mercury and increase the yield of gold by adding to the contents of the pan all sorts of chemicals to "doctor" the "sickened," that is, floured mercury.

These chemicals are generally mixtures of sulphate of iron, sulphate of copper, salt, lime, soda, etc. This kind of "doctoring" may be effective in some cases, but it is seldom practiced with intelligence. Where the percentage of concentrates is limited, and where there are a number of mines, it is common for some enterprising man to set up a smelting or chlorination work which is made large enough to deal with the concentrates of the district. I will not take time to describe the various processes of smelting, nor could it be done at any evening *sederunt;* but we may bear in mind that all smelting processes end in alloying the gold with lead, and cupeling in the usual way, with which we are all familiar. Because of the obvious impracticability of smelting, requiring well built brick furnaces, coal, fluxes, etc., at the typical gold mine high up on the mountain range, possibly near or beyond the timber line, chlorination is much more commonly practiced, and consequently merits a full description. In giving this description, I will confine myself chiefly to the old standard Plattner process as I have seen it practiced in California, where timber is abundant and cheap.

The first and essential operation prior to chlorination proper is roasting. It is obvious that a mixture of sulphides and arsenides of iron, copper, lead, zinc and metals generally will absorb an almost unlimited amount of chlorine, so that the small proportion of gold present would fare badly in a general scramble of the molecules for chlorine. That the metals may have the least opportunity to combine with chlorine, the sulphur is expelled, and their affinities satisfied as far as possible with oxygen by roasting. The roasting is generally done in a large reverberatory furnace, that has no very noteworthy feature in its construction. The concentrates are charged into the furnace at the cold end, heated very gradually, continually stirred and slowly worked forward into the hottest part, care being taken to admit air freely during the whole operation. Where chlorination is practiced on the most extensive scale, this roasting generally takes about 24 hours, and consumes from a minimum of half a cord to a cord of wood per ton, roasted. (A cord of wood gives about as much heat as a ton of coal.) It is a common saying that the success of chlorination depends more on the furnaceman than on the chlorinator, and on looking into hard chemical facts, we find that this is really the case, for if only one-half per cent. of iron were left unoxidized, it would absorb nearly one per cent. of chlorine, equal to about three per cent. of bleaching powder, and all this before the gold gets a single molecule of chlorine.

Toward the end of the roasting, and about fifteen or thirty minutes before the ore is discharged from the furnace, it is usual to stir in a small proportion of common salt. The object of this is to satisfy with chlorine, as far as possible, copper, zinc and other metals whose oxides have a tendency to form chlorides when they get chlorine presented to them in the free state. This chloridizing device is, however, only partially effective, as the chlorides formed are apt to be immediately decomposed under the influence of hot air, and in the case of lead the oxide or sulphate will not combine with chlorine in the furnace, but combines with it readily when offered moist and at the ordinary atmosphere temperature. The roasted and oxidized ore is now sprinkled with water to make it slightly moist, and is then charged into a wooden vat having a perforated false bottom.

The chlorine, generated at an outside source, is led in between the true and false bottoms, and gradually permeates upward through the mass of the porous ore.

The small amount of water held by the ore then becomes a saturated solution of chlorine, which gradually acts on the gold, so that in the course of one or two days it may be washed out as the soluble chloride by a further amount of water. This weak solution of chloride of gold is run into a tank, a solution of ferrous sulphate added, precipitate of gold allowed to settle for 48 hours, if possible, and the supernatant solution allowed to flow off. When sufficient gold precipitate has accumulated, it is collected and run into bars. Besides the Plattner form of chlorination which I have described, there are others which vary from Plattner and among themselves in the manner of application of the chlorine—most of them using revolving barrels instead of open vats for the chlorination proper. The best known of these are:

The Mears process, where chlorine is used under its own gaseous pressure.

The Newbery-Vautin, where air pressure is used.

The Pollok, recently described before this section of the society, where hydraulic pressure is used, and the Thies, where the chlorination is done in a barrel without any pressure, as described in this journal, 1889, 895.

Let us now return to the mine. The deeper we sink down into the reef, we find that while the richness of the ore may remain constant, the proportion of free gold, that is, amalgamable gold, becomes smaller and smaller, while the proportion of gold-bearing sulphides becomes greater and greater until we come to the water level, where it often happens that the free gold leaves entirely and becomes wholly refractory—that is, non-amalgamable. The water level is generally regarded as the point where the atmospheric and weather influences cease, and that down to that point the rain water has penetrated and gradually washed away the oxidizable base metals, leaving the inert gold in the crevices of the equally inert quartz, whereas, the ore found below the water level, not having been subjected to oxidizing influences, retains all its metals untouched and unchanged.

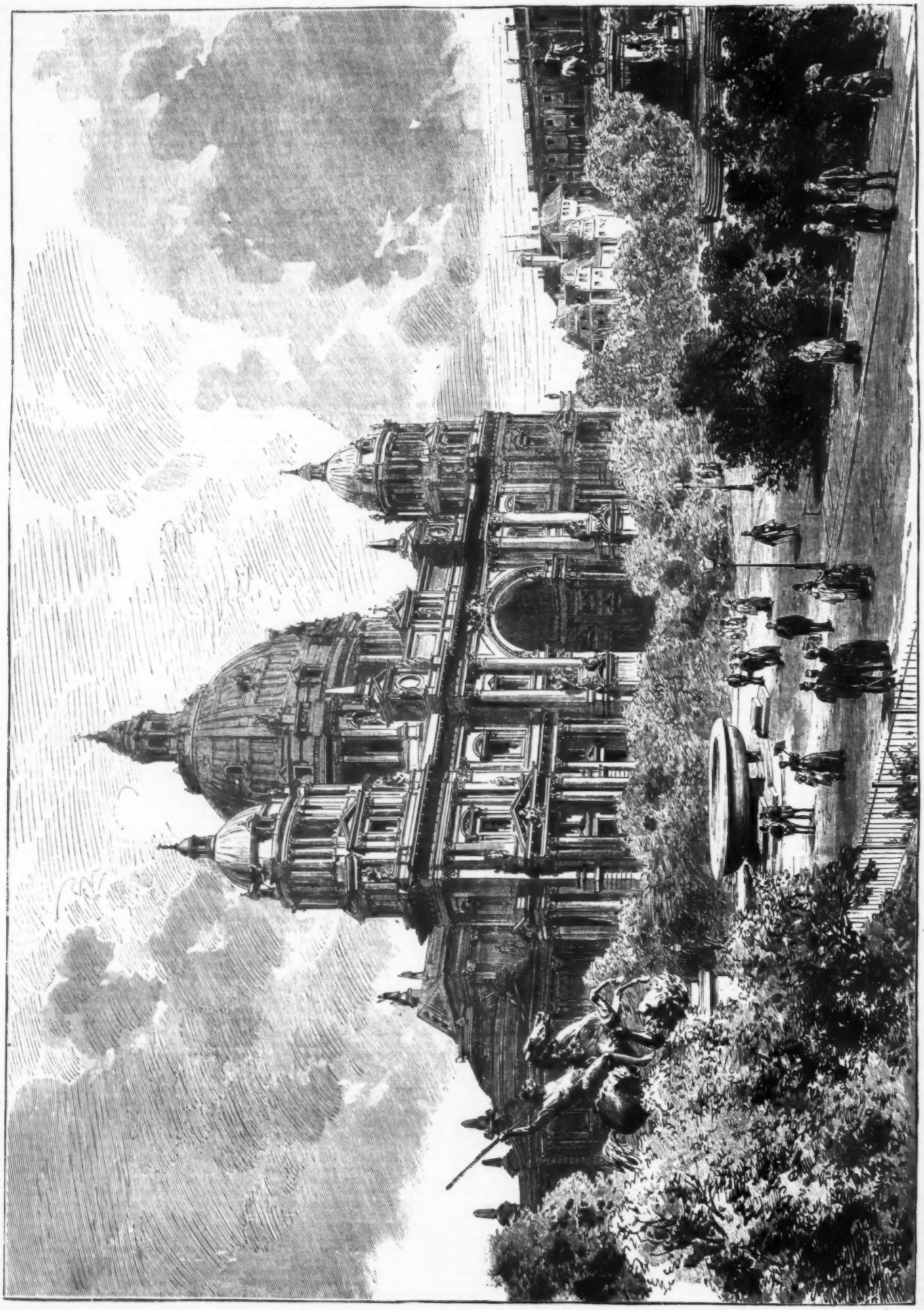
An interesting problem now presents itself. An ore consisting of a complex mixture of silica and the various compounds of iron, copper, lead, zinc, antimony, arsenic and sulphur (for convenience I will include all these compounds under the general term sulphides) and gold in the proportion of 10,000 parts of silica and sulphides to one part of gold, is very much richer than the average auriferous ore, and the question is, how can we best separate the one from the ten thousand? Under favorable circumstances, the gold and the useful metals may be recovered by smelting, but these favorable circumstances, which are proximity of the gold mine to coal, clay, limestone and other fluxes, are quite exceptional, as auriferous reefs are generally found in primary formations. As before implied, chlorination is frequently inapplicable—no attempt is ever made to chlorinate gold ore containing an appreciable quantity of lead—and where applicable is always troublesome and never cheap. When this question presented itself to Dr. Forrest and myself, we tried to find some solvent which, unlike chlorine and mercury, would have a stronger affinity for gold than for sulphides. Acting on this principle, we drew out a list of all probable or possible solvents fulfilling this condition. This list included cyanides, and we found that these salts solved the problem.

Our experiments were conducted first on a small scale, and on ores of all kinds and from all mines in all parts of the world. The result of these small trials was so satisfactory that we gradually worked from less to more, and in no long time larger quantities were worked, and now the process is in or on the eve of being put in operation in all quarters of the globe. I have now much pleasure in describing the method of working most generally applicable. The ore is ground to about the fineness of sea sand. If, instead of ore, we are working tailings from the amalgamation process, these are generally not to be reground, but treated as delivered. The finely divided material is mixed with a solution of a cyanide, say cyanide of potassium, containing on an average 0·4 per cent. of cyanogen as the cyanide of potassium or other alkali or alkaline earth. The ore and solution are stirred together for about six hours, more or less, this being the average time required to dissolve the gold: in practice the time required is determined by direct experiment. When the gold is known to be dissolved, the pulp is discharged into an ordinary filtering tank, where the filtration may if necessary be assisted by suction, and where the ore is washed by water or by the waste cyanide solution from a previous operation. The ore, after treatment with cyanide solution, is unchanged to the eye, as almost nothing but the imperceptible proportion of gold present has been removed. The gold now being in solution, the next object is to get it precipitated, and here we encounter a serious difficulty. Gold and cyanogen have such a strong mutual affinity, that it is difficult to get any substance that will separate them. The gold cannot be precipitated by any ordinary method, such as the use of ferrous sulphate or oxalic acid; even sulphureted hydrogen and sulphide of sodium will not precipitate gold from its cyanide solution, though they precipitate silver. On referring to books on electro gilding, we got no assistance, as the invariable method given for the recovery of gold from cyanide solutions was, evaporate to dryness and fuse the residue. We had noticed, however, by experiment, that zinc precipitated gold very feebly, and tried this in the same way that copper is precipitated from its ordinary solutions by scrap iron, but scrap zinc had no effect; then granulated zinc was tried, with a most imperfect and disappointing result; then heating in presence of scrap and granulated zinc, but this had only the effect of forming urea, and assisting the precipitation very little indeed. Further, we tried zinc dust, but still there was no success; finally, we prepared some zinc in a form like sawdust, porous and with a large surface of bright metal. On allowing the cyanide of gold solution to trickle through a mass of the zinc, we found that it trickled out gold free, and better still, we found that the action became more vigorous and pronounced after a portion of the gold had been precipitated on it, doubtless as gold and zinc formed together a more powerful electro-chemical precipitant than zinc by itself. An arrangement of a porous mass of zinc like a sponge formed a chemical filter, which at once precipitated and collected the precious metal; indeed, so like an ordinary water-purifying device was this zinc filter, that many non-technical visitors formed and held tenaciously to the idea that the gold was in suspension in the cyanide solution, and the zinc was used merely because of its durability.

Improvements in detail were made in the direction of increasing the surface and decreasing the weight of the zinc, till now we have it in threads, 1 lb. of which occupies about two gallons measure. The zinc in this form is possessed of enormous chemical activity, of which the strongest and most direct evidence is the fact that it burns in the air like thin shavings of wood. When the gold has been deposited, it is necessary to separate it from the excess of zinc present. The filiform structure of the zinc, and the exceedingly fine powder, as which the gold is deposited, render this an easy matter. The filiform mass of zinc, with gold powder adhering, is vigorously shaken in water, when the gold falls off, and the fibrous particles of the zinc may be collected in a sieve. The gold settles easily, is collected, and fused directly into bullion.

Having now described the chief points in the process from the technical standpoint, let us look at the purely chemical aspect it presents. Reference has already been made to the fact that a cyanide solution acts on the gold in ores in preference to the sulphides of base metals with which it may be combined or associated. This selective action is the keystone of the whole process. It is known that metallic gold is dissolved by a cyanide; it is also known that sulphides of copper, zinc and iron artificially prepared are readily acted on by a cyanide solution; but we found a very different state of affairs in treating ores where these or similar compounds exist prepared by the hand of nature herself. Nature seems to render the base metallic compounds insoluble, while the gold combined with or contained in them is more easily acted on than the metal itself. This at once raises the question, how does gold exist in base refractory ores? Is it combined or free? This question I admit I cannot answer satisfactorily to myself. Judging from theoretical considerations only, I think gold should exist almost invariably in the free state, for if we assume that sulphides, pyrites, etc., were formed by deposition from aqueous solution, the gold would be deposited in the metallic state. This may be shown by dropping some powdered pyrites into a solution of chloride of gold, when gold will be precipitated as metal; on the other hand, let us assume that the pyritous formations carrying gold were formed by igneous agency. In this case the gold ought to be metallic, too, because any sulphide of gold already existing would be decomposed by the high temperature, and of course sulphide of gold cannot be formed at a high temperature. It is true that sulphide of gold may combine with any alkaline sulphide and resist decomposition by heat, but such a combination as a matter of fact does not occur in nature. Telluride of gold, and I think antimonide of gold, are not decomposed by heat, but they occur in small quantities only and do not affect the general argument. In spite of these theoretical considerations, however, we have strong evidence to show that gold exists in several different states of combination or molecular structure. Let me give one case in illustration.

A sample of tailings from the ordinary process of stamping and amalgamation was received, and I think it may safely be assumed that the mercury had extracted some gold from the ore which produced these tailings. We treated the finely ground tailings by alkaline solution of bromine, which extracted a considerable portion of gold, and the bromine treatment was repeated time after time till it ceased to extract gold; then it was treated with a hot solution of ferric bromide, which yielded a further quantity of gold. This treatment was repeated time after time till it ceased to extract gold, and finally the residue of tailings was smelted and a still further quantity of gold produced. As this ore yielded its gold in stages to the four different processes of amalgamation, treatment with bromine, treatment with ferric bromide and smelting, we infer that the gold existed in four different states, mechanical or chemical. Notwithstanding the complex nature of these tailings, which consisted of all sorts of sulphides with the fourfold gold, the cyanide acted on it almost perfectly, extracting 93 per cent. of the precious metal, while the higher extraction by any of the bromination methods was about 40 to 50 per



PROF. JULIUS RASCHDORFF'S DESIGN FOR A NEW BERLIN CATHEDRAL.—Drawn by G. Theuerkauf.

cent. The cyanogen seemed to have an affinity for gold and a power of penetration so much stronger than mercury or bromine, that it broke through barriers impregnable to them and captured the gold. Elsner has stated metallic gold dissolves in cyanide of potassium only in presence of oxygen. Not having seen the original account of Elsner's researches, I am not in the position to criticise his experiments, but I never could find that the presence of oxygen was necessary either to dissolve gold by itself or from ores by cyanide. If a piece of gold be immersed in a cyanide solution so that air to act on it would have to penetrate two inches or three inches of the solution, the gold will dissolve in its usual slow and steady fashion. The equation shows that either oxygen must be absorbed or hydrogen evolved. I have seen no evidence of the former, and can adduce no proof for the latter, but I think the latter the more probable, because I cannot conceive oxygen penetrating even a film of cyanide solution without at once oxidizing the cyanide to cyanate, whereas in the other case, as suggested to me by my friend Mr. Ellis, the nascent hydrogen may be at once seized by the excess of cyanide present and ammoniacal compounds formed. However, we do not concern ourselves much with the reactions of pure gold, but as a matter of fact we cannot find that oxygen plays any part in the cyanide extraction of gold from ores. We have treated an ore with cyanide with free access of air, and then a parallel experiment was done with boiled water, the bottle filled to the stopper with solution and ore, and the stopper sealed. The extraction was the same in both cases.

We have so far only considered ores which are refractory from chemical as well as mechanical causes, but ores are frequently found in which the gold is refractory from a purely mechanical cause, which is the extremely fine division of the gold. The cyanide process is quite as applicable to this class of ore as any other. These ores are generally spongy and absorbent, and this, we find, enables us to dispense with stirring the ore and cyanide solution together, the same end being accomplished by allowing this cyanide solution to percolate slowly through the mass—a clear saving in power.

The advantages claimed for the cyanide process over smelting and chlorination are: As compared with smelting, it requires no furnaces and no coal, and no fluxes, and thus may be used successfully in remote situations where smelting is utterly impossible. As compared with chlorination, cyanide process involves no roasting, therefore no furnaces and no fuel. Moreover, by the cyanide process, ores containing lead, zinc or earthy carbonates, which cannot be worked to profit by chlorination, may be easily and profitably treated as any other. For chlorination, about seven per cent. of the weight of the ore to be treated often has to be carried to the ore in the form of bleaching powder, say 1¼ per cent., bisulphate of soda 2 per cent., and sulphate of iron 2½ per cent., with packing say of 1 per cent., whereas about 1 per cent. of the ore to be treated will cover the weight of the necessary cyanide, zinc and packing. Thus, by chlorination, one ton of chemicals will treat only about 14 tons, whereas by the cyanide method one ton will treat 100 tons.

Moreover, chlorination does not extract any silver, but by the cyanide method the most of the silver—invariably associated with gold in ore—is extracted along with the latter metal at the same operation. For the sake of simplicity, I have not named silver in the body of this paper, but the remarks made in reference to gold generally apply to the silver associated with it.

From what I have seen of gold mines and gold mining in the Sierra Nevada, in the Rocky Mountains, in the Southern States of America, in Nova Scotia, from the many kinds of ore I have seen from all parts of the world, and from what I know of the selective and energetic action of cyanides, I confidently predict that cyanide of potassium, hitherto used only to polish amalgamated plates, will take a front rank as chief agent in gold extraction.—*J. S. MacArthur, in Journal of the Society of Chemical Industry.*

THE NEW CATHEDRAL FOR BERLIN.

IN these times of renewed religious life it seems very remarkable that the capital of Germany should still be without a cathedral, in spite of the fact that plans for such a structure have been considered by each successive ruler for the last two hundred years; but, thanks to the energetic action of the present Emperor, these plans are nearer completion now than ever before.

The old Berlin Cathedral, on the western side of the present *Schlossplatz*, was originally a Dominican church and dated back to the 13th century. In 1536 Joachim II. changed it to a collegiate church and had it connected with the palace by a special passage. This elector and his father, Joachim Nestor, were the first Hohenzollerns that were buried in the Berlin Cathedral. That was the beginning of the present royal mausoleum.

Frederick II. erected the present church on the *Lustgarten*, but it is so bare and unpretentious that the term "cathedral" when applied to it seems like a high-sounding exaggeration. Competitive designs for a cathedral were made during the reign of King William I., but the great war and the founding of the empire interfered with all such undertakings. The plan was thus handed down from generation to generation. When Emperor Frederick was Crown Prince, he had designs made for a monumental structure to be erected on the spot where the present cathedral stands. The richness and magnificence of these plans excited a great deal of remark when they were published three years ago. They provided for a large central auditorium with a great dome, especially suited for grand national festivals; and on one side of this was arranged the church in which services would be held, and on the other, the mausoleum. The royal palace was to be connected with the cathedral by a gallery, and was to be ornamented by a high tower.

Unfortunately these plans proved impracticable on account of the immense expense they would have incurred; but they have been simplified and reduced, although the fundamental idea has been retained, until it was finally possible to lay before the Prussian Landtag a project calling for about $2,500,000. The cathedral, as it is now planned, will consist principally of a domed church that will accommodate 2,000 people, with the mausoleum at the north, and to the south, toward the palace, a chapel for wedding and baptismal services. The measurements of the dome have been reduced to about 98 ft., but large galleries have been provided for the court, diplomats, officials, and the singers. The altar is to be on the east side in the high, semicircular choir, and the pulpit on the southeast side. The architect, Geh. Regierungsrath Prof. Raschdorff, and his son, Prof. Otto Raschdorff, have made a thorough examination of all notable domes of the seventeenth and eighteenth centuries, with a view of obtaining the best conditions for acoustic and lighting purposes. The chapel on the south side is to be provided with 100 seats and to have a special entrance from Kaiser-Wilhelmbrucke. The architecture of the mausoleum, with its halls and arches, will be especially rich; its light and airy spaces would have satisfied the desire of Emperor Frederick for a worthy mausoleum for the Hohenzollerns. Besides many of the early rulers, and numerous princes of the Hohenzollern house, the Great Elector and King Frederick I. and his consort will find their last resting place here, in their old sarcophagi.

The entire edifice will have a front of 295 ft. on the *Lustgarten* and will cover a surface of about 64,583 sq. ft., or double the size of that covered by the old cathedral. The style of the architecture will be chiefly Renaissance, that being best suited to the surroundings. The main feature of the structure will be the dome, which will be 360 ft. high. The entrance is skillfully arranged in the long front on the *Lustgarten*, and this portion is connected with the other parts of the edifice by little towers. The height of the main portion of the structure is the same as that of the palace, or about 98 ft. All details of the architecture of the exterior, as well as of the interior, have received the most careful attention. It is expected that the cathedral will be completed in January, 1900.

The chief architect, Geh. Regierungsrath Prof. Julius Raschdorff, was born at Pless, in upper Silesia, in 1823, completed his studies of the erection of public buildings in 1853, and soon after was elected city architect of Cologne. There he built many notable structures and also attended to the reconstruction of the Rathhaus and other buildings. In 1878 he was called to the technical high school in Berlin, as professor. While here he completed the technical high school

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at Charlottenburg, and built the English church in Monbijou Park, as well as the mausoleum for Emperor Frederick. Prof. Otto Raschdorff has, for many years, been his co-laborer, and he also has, for some time past, been an instructor at the technical high school.—Abstract of article by P. Walle in *Illustrirte Zeitung.*

BAGASSE AS FUEL.*

IN order to meet the present low price of sugar and almost valueless molasses, under the bounty law and with the possibility of the bounty not lasting many years, it becomes absolutely necessary to reduce the cost of sugar manufacture.

The judicious use of bagasse as fuel is perhaps one of the most important questions with which we have to deal, and which has a direct bearing on the reduction of the cost of manufacture.

There is a general tendency among people connected with the sugar industry of Louisiana to disregard bagasse in all calculations, being a by-product costing nothing. Were it not for the expense and bother of carting it away, even at this late day, few people would take the trouble to burn it.

Nevertheless, since bagasse contains "carbon," it has an intrinsic fuel value equal to the additional cost of that proportion of coal necessary to do the work which the bagasse is capable of performing. Appreciating the difficulties which surround the practical determination of this value on a manufacturing scale, it is perhaps best to try and establish it in the abstract. That is to say, as a source of heat, regardless of the manner in which this heat is to be applied.

In an article from the pen of Mr. N. Lubbock, published in *The Sugar Cane* for October, 1891, and reprinted in the *Bulletin de l'Association des Chemists de Sucrerie et de Distillerie de France et des Colonies*, the author, after calculating the number of "heat units" obtainable from the "carbon" contained in the fiber and other organic substances of bagasse, deducting that proportion of heat lost in waste gases in vaporizing the moisture and heating the air of combustion, concludes that to produce the same number of available heat units contained in one pound of Scotch coal requires 4·83 pounds of bagasse from a double mill making a 72 per cent. extraction, and 5·98 pounds of single mill bagasse of 66 per cent. extraction.

These figures cannot very well be applied to Louisiana cane, for his calculations appear to be based on tropical cane containing 12½ per cent. woody fiber, against say 10 per cent. for ours.

A common impression obtains that within certain limits a low extraction gives bagasse most valuable as fuel, owing to its sugar content. The above figures show the contrary to be the case. In the first place 100 pounds of low extraction bagasse contains a smaller proportion of woody fiber, more water and not a sufficiently increased quantity of combustible organic salts to supply the heat units lost in the woody fiber. Secondly, since the lower extraction bagasse contains more water, a greater proportion of heat units have to be expended in vaporizing it, thus leaving a smaller margin of available heat units.

For instance, with cane containing 12·5 per cent. woody fiber, a juice containing 16·13 per cent. solids and 83·87 per cent. water, bagasse of say 66 per cent. and 72 per cent. mill extraction would have the following percentage:

Composition, viz.:	66 p. c. bagasse.	72 p. c. bagasse.
Woody fiber	37	45
Water	53	46
Combustible salts	10	9
Totals	100	100

This shows that 72 per cent. bagasse contains 54 parts of combustible matter against 47 parts for 66 per cent. bagasse, which is an excess of nearly 13 per cent. in favor of 72 per cent. bagasse.

In addition to being inferior in heat-producing properties, the 66 per cent. bagasse contains 15·2 per cent. more water to be evaporated, before the heat produced by the combustion of the bagasse becomes available for manufacturing purposes.

The author referred to states that the woody fiber contains 51 per cent. "carbon," and the sugar and other combustible matters an average of 42·1 per cent. At 12,906 units of heat generated for every pound of carbon consumed, the 66 per cent. bagasse is capable of generating 297,834 heat units as against 345,200, or a difference of 47,366 units in favor of the 72 per cent. bagasse.

Assuming the temperature of the waste gases to be 450° F., that of the surrounding atmosphere and water in the bagasse at 86° F., and the quantity of air necessary for the combustion of one pound of carbon at 24 pounds, the lost heat will be as follows: In the waste gases, heating air from 86 to 450° F., and in vaporizing the moisture, etc., the 66 per cent. bagasse will require 112,546 heat units, and 116,150 for the 72 per cent. bagasse.

Subtracting these quantities from the above, we find that 66 per cent. bagasse will produce 185,288 available heat units, or nearly 38 per cent. less than 72 per cent. bagasse, which gives 299,050 units. Accordingly, one ton of cane at 66 per cent. mill extraction will produce 680 pounds bagasse, equal to 125,995,840 available heat units, while the same cane at 72 per cent. extraction will produce 560 pounds bagasse, equal to 167,468,000 units.

We therefore find that, after taking everything into consideration, one ton of cane at 72 per cent. mill extraction will produce for steam-making purposes 41,472,160, or about 33⅓ per cent. more available heat units than the same cane at 66 per cent. mill extraction.

It follows, from the foregoing, that in order to be accurate, every case should be handled separately. To do this would require more time than the writer can devote to an article of this character. He believes, however, that, assuming say 75 per cent. average mill extraction from Louisiana cane, containing say 10 per cent. woody fiber and 16 per cent. total solids in the juice, a fair average value can be placed on bagasse from double mills.

By making the same calculations that were made in the case of tropical cane, bagasse from one ton of Louisiana cane contains 157,395,640 heat units, from which 56,146,500 have to be deducted.

This would make our 75 per cent. Louisiana bagasse worth on an average of say one-half barrel, or nearly 92 pounds coal per ton of cane ground. Under fairly good conditions, 1 pound coal will evaporate 7⅛ pounds water, while the best boiler plants evaporate 10 pounds. Therefore under fairly good conditions the bagasse from 1 ton of cane at 75 per cent. mill extraction should evaporate 689·25 pounds of water, and under the best conditions 919 pounds water. The juice extracted from such cane would under these conditions contain 1,260 pounds of water. If we assume that the water added during the process of manufacture is 10 per cent. (by weight) of the juice made, the total water handled is 1,410 pounds. From the juice represented in this case, the commercial masse cuite would be about 15 per cent. of the weight of the original mill juice, or say 225 pounds. Said mill juice 1,500 pounds, plus 10 per cent., equals 1,650 pounds liquor handled; and 1,650 pounds, minus 225 pounds, equals 1,425 pounds, or about the quantity of water to be evaporated during the process of manufacture. To effect a 7⅛ pound evaporation requires 190 pounds of coal, and 142½ pounds for a 10 pound evaporation.

To reduce 1,650 juice to sirup of say 27° Baumé, or 50 per cent. brix, requires the evaporation of 1,170 pounds of water. If this work be accomplished in the open air, it will require about 156 pounds of coal at 7⅛ pounds boiler evaporation, and 117 at 10 pounds evaporation.

With a double effect the fuel required would be from 59 to 78 pounds, and with a triple effect, from 36 to 52 pounds.

To reduce the above 480 pounds of sirup to the consistency of commercial masse cuite means the further evaporation of 255 pounds of water, requiring the expenditure of 34 pounds coal, at 7½ pounds boiler evaporation, and 25½ pounds with a 10 pound evaporation. Hence, according to our premises, to manufacture one ton of cane into sugar and molasses, it will take from 145 to 190 pounds, equal to from 0·30 to 0·54 barrel additional coal, to do the work by the open evaporator process; from 85 to 112 pounds, equal to 0·11 barrel coal with a double effect, and only 7½ pounds evaporation in the boilers, while with 10 pounds

*A paper read by Prof. L. A. Becnel before the Louisiana Sugar Chemists' Association, March 12, 1892.—*La. Planter.*

PROF. JULIUS RASCHDORFF'S DESIGN FOR A NEW BERLIN CATHEDRAL.—DRAWN BY G. THEUERKAUF.

boiler evaporation the bagasse alone is capable of furnishing 8 per cent. more heat than is actually required to do the work. With triple effect evaporation depending on the excellence of the boiler plant, the 1,425 pounds of water to be evaporated from the juice will require between 62 and 86 pounds of coal. These values show that from 6 to 30 pounds, or from 0·02 to 0·16 barrel of coal, can be spared from the value of the bagasse to run engines, grind cane, etc.

It accordingly appears that with the best boiler plants, those taking up all the available heat generated, by using this heat economically the bagasse can be made to supply all the fuel required by our sugar houses. If this has not yet been accomplished in Louisiana, may it not be due more to imperfect boiler and evaporating plants than to a deficiency in heat-producing properties of the bagasse used? In conclusion, the writer firmly believes that the day is not far distant when the only additional fuel used will be that needed to start mills, burners, and to boil when the mills are not running.

ON THE DURABILITY OF MODERN PIGMENTS IN OIL.*

By A. P. LAURIE, M.A.

PROFESSOR CHURCH, in his recent book on "Chemistry of Paints and Painting," has drawn up a selected palette of twenty-five pigments suitable for oil painting. He divides them into two groups.

Section I. contains:

Flake white.	Vermilion.
Cadmium yellow.	Madder carmine.
Cobalt yellow.	Light red.
Yellow ocher.	
Viridian.	Raw umber.
French ultramarine.	Cappagh brown.
	Ivory black.

Section II. contains:

Raw sienna.	Purple madder.
Naples yellow.	Madder brown.
Baryta yellow.	
Green oxide of chromium.	Cobalt blue.
Terre verte.	Prussian blue (insol.)
Malachite.	Burnt sienna.
Emerald green.	Caledonian brown.

This selected palette is the outcome of many years of experimenting, and of useful observation of the behavior of pigments. It is also, I believe, sufficiently complete to supply all that is needed in painting a picture. On the other hand, it cannot be regarded as final. Doubtless, as our knowledge increases, certain pigments will be excluded from this list, and others introduced. It will be necessary to subject it to a careful and detailed criticism from time to time. It has seemed to me, however, better to confine myself to this palette than to conduct experiments over the whole range of pigments, although there are pigments which have been excluded, and which are worthy of another trial.

Among the reasons for doing this, I may point out that there is a tendency to useless repetition in the experiments on this subject, and to proving again and again that certain pigments are fugitive. Surely the fate of certain colors has been finally settled, and they need be no further considered.

I have also been limited in range by the fact that I have set myself to prepare most of the pigments experimented upon, and to prepare them in such a form that they should be equal in color, etc., to the commercial specimens. The importance of doing this is obvious. We can only hope to arrive at accurate knowledge on this subject by preparing the pigments experimented upon, and knowing their history and what they contain.

This is a most laborious task, however, as published recipes are almost useless, and months of experimenting were usually necessary before a single pigment mentioned here could be satisfactorily produced.

In order to make the paper complete, the recipes used in the preparation of the pigments should be published in full. This is impossible at present, though they are all carefully recorded, and will ultimately be made public.

This paper, then, is merely a few notes on Professor Church's palette, not pretending to exhaust the subject, and to be added to, from time to time, as fresh results are obtained.

Let us begin our illustration of this palette by selecting from it the pigments which require careful preparation and careful testing before being finally included. They are: Cadmium yellow, cobalt yellow, vermilion, madder carmine, French ultramarine, Naples yellow, baryta yellow, purple madder, madder brown, malachite, emerald green, Prussian blue—all these pigments are artificial, except malachite, which is of little importance; and much will depend on the method of preparation, careful washing, exclusion of dangerous impurities, and freedom from gross adulteration. The other pigments in the list are permanent, if genuine; and, therefore, all that is necessary is to look out for adulteration.

To take, then, the yellow pigments mentioned in the first column, and to begin with *cadmium yellow*, careful readers of Professor Church's book will find that he refers to only one shade of this yellow as being perfectly safe, an orange-yellow shade. The pale cadmiums are notoriously fugitive, and contain free sulphur, while the deep orange cadmiums seem apt to change into the yellow varieties.

I have been trying, myself, to obtain a cadmium of a pure light yellow which shall contain no such objectionable constituent as free sulphur, and shall also be molecularly stable. I have been preparing some lately which I subject to a dull red heat before grinding. This ought to increase molecular stability, and would, of course, prove destructive to pale cadmium made the usual way. I do not feel justified in publishing the process as yet, but I think the pigment is worthy of a trial, as it ought to be stable.

Cobalt Yellow (Aureoline).—This pigment (a nitrite of cobalt and potassium) I have prepared from a recipe very similar to the one given by Professor Church. I find, after thorough washing, and grinding in oil, that it is not affected by twelve months' exposure out of doors toward the south; so that, as far as my tests go, I can confirm Professor Church's good opinion of it.

Yellow Ocher.—I have recently had my attention directed to a most objectionable adulteration of yellow ocher with lead chrome yellow. Out of seven samples of Oxford ocher sent me by wholesale dealers in pigments, two contained chrome yellow. One of the two consisted very largely of whitening, tinted with chrome, and mixed with a small quantity of a pale ocher. The result was a sample which looked as bright as the best samples of genuine Oxford ocher. Professor Church mentions adulteration with yellow lake. I have never yet met with a case of this.

Vermilion.—I have described at length elsewhere my experiments on this pigment. I find many English samples to contain alkaline sulphide, and prefer genuine Chinese vermilion. The following are the percentages of ash found in different samples of Chinese vermilion obtained direct from China:

(1)	(2)	(3)	(4)	(5)	(6)
0·1	0·1	0·06	0·12	0·06	0·04

Some of the English vermilions can be very much improved by washing with weak acid, as the following analysis shows:

Ash before washing	0·52 per cent.
Ash after washing	0·14 per cent.

All vermilions, including the best Chinese vermilion, blacken in sunlight, but are, I believe, stable pigments when exposed to the diffused light of a room or gallery.

Madder Carmine.—The madder lakes I have experimented on are of my own making, and are prepared by dyeing well washed alumina with artificial alizarine, and again thoroughly washing. I have prepared a purple, a ruby, and a rose madder. After a year's exposure, the purple has, possibly, lost a little, the ruby is unchanged, and the rose has very slightly faded, and become purpler in tint. They are all, practically, unaltered, but with a slight advantage in favor of the ruby madder.

The only other pigment open to question in this palette is French ultramarine. I have not made any experiments on this pigment, and shall, therefore, pass to Section II.

Naples Yellow.—I find no difficulty in preparing a real Naples yellow, that is a compound of oxide of lead and antimony of a fine color, but have not exposed it for a sufficient time to test its durability.

Baryta Yellow, or Lemon Yellow.—Professor Church points out that lemon yellow is often a strontium, not a barium chromate, and that the barium chromate is much the most permanent of the two. I have, therefore, only experimented on the barium chromate, preparing it myself. It seems to me to lose slightly in brilliancy after twelve months' exposure. As lead chrome and Prussian blue are known to be mutually destructive, I thought it as well to test a mixture of barium chrome and Prussian blue. I find that a bright green is produced, which is only slightly dulled by twelve months' exposure. Here and there the Prussian blue seems to have faded, causing the yellow to show up through it a little more, but they do not seem to have any injurious action on each other.

Purple madder I have already referred to, and I have not tested *brown madder* of my own making for a longer period than six months; for that period it was not affected.

The next two pigments of doubtful stability are malachite and *emerald green*. Malachite is so little used that I have not experimented on it. I have described elsewhere the property which emerald green possesses of slightly dissolving in the linseed oil, and slowly diffusing through it after it is dry. It is, of course, fatal both to cadmium yellow and vermilion, turning them black. For this reason, I think it is better rejected, or, if used, only occasionally by itself, and far away from any cadmium yellow on the picture. I should advise the introduction of cobalt green into the palette. It is a durable and beautiful pigment.

Prussian Blue.—It is very difficult to try Prussian blue that has been properly washed. It is apt to contain as much as 0·3 per cent. of free sulphuric acid, and often large quantities of potassium ferrocyanide. English makers are, in my experience, peculiarly careless; and I find it best to buy Prussian blue in Germany. It is troblesome to make. The blue I have obtained from there never contains more than 0·01 per cent. of free acid, so that it is easily washed sufficiently. I have had some of a perfectly washed blue exposed for twelve months. I find it has faded somewhat, and become greener in tint. It must be remembered, however, that, in the dark, Prussian blue recovers, so that it should be stable in an ordinary room. I find it may be mixed with cobalt yellow with impunity. All the other pigments in this palette are of undoubted stability, and are above question.

In the course of these notes I have referred more than once to the effect of light on these pigments. My method of testing this was as follows:

I selected an attic window looking nearly due south, and I hung outside of it a wooden frame, into which I could slide glass plates (half plate size). After preparing, washing, and drying a pigment, I ground it in pure cold-pressed sun-refined linseed oil, and rubbed it out on two glass plates, getting the two patches of color to look as nearly the same as possible. I put them both away to dry, and after they were dry I slipped one plate into the frame and put the other away into a plate box. In this way the plate outside was exposed to all the weather and sun for twelve months, from September to September. The pigments tested were:

Twelve Months.

Ruby madder	Unchanged.
Rose madder	More purple, very slightly faded.
Purple madder	Perhaps very slightly faded.
Cobalt yellow	Unchanged.
(Barium) Lemon yellow	A little duller.
(Chinese) Vermilion	Black, or dirty brown.
Prussian blue	Faded, greener.

Six Months.

Brown madder	Unchanged.

These tests were of such exceptional severity, the exposure being outside, that I do not think any of these pigments should be removed from the selected palette, as they have practically (with the exception of vermilion) proved permanent. The reasons for not distrusting vermilion have been given elsewhere. As far, then, as my experiments have gone, I should only exclude emerald green from this palette, provided the pigments mentioned are properly prepared, and with such restrictions as the avoidance of impure vermilion and of pale cadmium yellow, as at present manufactured. Of the other pigments, the most affected by exposure (after vermilion) is Prussian blue. Of the other blues, of course cobalt blue is perfectly safe, but French ultramarine requires careful testing.

On the whole, however, this palette seems to me a very trustworthy one, and not at present open to much improvement. There are, however, various pigments excluded which are worthy of further trial, and may ultimately be reintroduced.

In all these experiments the pigments have been merely ground in pure oil. Different vehicles have a powerful influence on the durability of many pigments, and are worthy of special study. I have treated of this, however, at considerable length elsewhere, and need not repeat my experiments here.

The results may be briefly summed up as follows: Linseed oil is permeable by moisture and gases, and consequently affords poor protection to pigments liable to be affected by moisture or certain gases.

The dissolving of resin in the oil, so as to make oil varnishes, such as copal oil varnish and amber oil varnish, has little or no effect in protecting the pigments, the moisture still penetrating.

Pure resin, when made into vehicles by solution in volatile liquids, and natural varnishes or balsams, such as Venice turpentine, *oleo de abezzo*, and others, do protect very effectively, excluding moisture and gases, and enhancing the durability of the pigment under adverse conditions.

(This probably accounts for the durability of most colored lacquer work from Japan, when natural varnishes are used, and there is some historical evidence to show that balsam was largely used by both Flemish and Italian painters on vehicles.)

Certain pigments are soluble in linseed oil. For instance, verdigris is readily, emerald green slightly, soluble. Such pigments diffusing through the oil may be very destructive.

They are not soluble to the same extent, if at all, in resin. These results, though of little practical application at present, may, I hope, lead to the discovery of an improved medium, which will protect and isolate pigments ground in it, and so add to the durability of pictures.

* Read recently before the Society of Arts, London.—*From the Journal.*

HOW LIEBIG'S EXTRACT OF MEAT IS MADE.

IT must be a matter of interest to the thousands of invalids all over the world, who are daily fed on extract of meat, to learn something of how and where the strangely stimulating, molasses-like substance is made. Everybody knows that the highly condensed preparation that comes put up in small white jars was invented by Baron Justus Liebig, the eminent German chemist, that it is universally used in hospitals and prescribed by physicians, as a tonic for the debilitated rather than as an article of food, although it is also largely employed as the foundation for various soups, sauces and made dishes, and for flavoring roasts, stews, game and fish. But most people believe that it is still manufactured in Antwerp, as formerly, and find themselves puzzled by the English trade mark.

A few years ago a British company purchased the business which Herr Liebig had founded half a century before, and in 1866 transferred the works to distant Uruguay. An idea of the magnitude of the industry may be gained from the fact that the company claims to sell eight million jars of the extract every year, and that eighty shiploads of it are annually sent from this manufactory to Europe. Each pound of extract is guaranteed to contain enough substance to prepare 190 portions of soup, equal in strength to that obtained by boiling forty-five pounds of meat for several hours. And thus we may infer how it was that the wise man who, centuries ago, declared there was "nothing new under the sun," is recorded in Scripture as having eaten "the strength of an ox" every day.

A traveler in this portion of South America will find it worth the slight expenditure of time and money required to visit these famous works, although a more unsentimental expedition cannot well be imagined, or one more trying to sensitive nerves before it is finished. Sail up the Rio de la Plata half a day's journey in a northwesterly direction—the shores invisible on a cloudy day and the billows yet so boisterous that you find it difficult to believe they are not of "the ocean wild and wide;" turn suddenly into the Rio Uruguay and sail due north another half day, and at length you will come to Fray Bentos—a little town on the Uruguayan shore of the mighty stream, which is here several miles wide and with a very strong and rapid current in its hurried rush to the sea.

Having passed several hundred miles of monotonous and apparently unoccupied country, with here and there an insignificant village whose inhabitants seem to be all dead or gone a-visiting, about the only signs of life being a few lean dogs blinking lazily in the sun, you are amazed to see in this remote interior a crowd of ships and steamers, floating the flags of England, Germany, France, Italy, and various South American countries, anchored in front of this equally insignificant-looking village. And in truth there is nothing about Fray Bentos of any consequence whatever except the Liebig factories, and they are a mile away, on a high, bold promontory jutting out into the river.

But no better place could be found in which a weary journalist may rest awhile from traveling, post up his note books, and prepare for pastures new. The town occupies another promontory, which also extends far into the river. It has a tolerable meson that answers for a hotel, macadamized streets, clean and wide, leading directly into a grassy sea of verdure that stretches away far as the eye can see, and a lovely plaza crowded with old trees, under whose drooping branches we propose to spend most of our waking hours during the next few days. But of course our

first business is to present our credentials from the Uruguayan government to the alcalde (an important personage in the rural districts, whose office corresponds to that of mayor in the United States), and send out a few letters of introduction which Montevidian friends have kindly furnished, thus securing to ourselves all the courtesies and hospitalities of the place. And next we must devote an entire day to visiting the Liebig works.

The factory grounds are surrounded by a lofty brick wall, entered through an imposing archway; and within the walls are many buildings, including machine shops, shops for tinsmiths, carpenters and engineers, all on a complete scale, so that necessary repairs can be made on the spot. A tramway runs from the works down to the fine, new iron pier where vessels are loaded with the "extract," and we notice that several ships are waiting for their cargoes. The workmen's cottages are clustered outside the walls, forming a considerable village, as more than a thousand men are employed who reside on the spot with their wives and children. First we are conducted to the private office of the manager, who insists upon serving us with champagne, crackers and cheese, from the handsome sideboard that is topped by a bust of Baron Liebig. We observe that there is an extensive library in the room, containing books in German, Spanish, French and English, a center table laden with English periodicals, blooming plants and singing birds in the windows, and pet cats and dogs that appear on chummy terms with one another and the world in general.

But business must be attended to, and while waiting for a clerk to show us over the works we gently draw out the genial manager and elicit the following facts: Work is carried on only seven months in a year, but during that time a thousand oxen are slaughtered every day, all good, sound animals, none less than four years old. Already, during the twenty-eight years they have been established here, upward of three million cattle have been made into extract, representing about forty millions of dollars in value. The company owns thousands of acres of the richest pasture lands in the world, in this republic and the Argentine, and hundreds of thousands of cattle. The extract leaves this place packed in large cans, each of which contains 110 pounds and the substance of fifteen animals, and is worth $250. It is sent direct to Antwerp, to the company's general depot, where it is examined by a special chemist employed for the purpose. After having received this gentleman's approval and guarantee it is potted in the small white jars with which we are familiar, packed in cases, and sent out to all the markets of the world. Though thirty-four pounds of lean meat are required to make one pound of extract, the substance does not contain as many nutritive as stimulative qualities, which act as excitants to the digestive organs and tend to restore the appetite, repair nervous waste and tone up the debilitated. Being entirely destitute of grease, albumen and gelatin, it cannot spoil nor lose its flavor, however long it may be kept in any climate.

Now brace your nerves for some unpleasant sights and let us follow the employe who has been detailed for the purpose and view the process of converting a huge, full-blooded ox in the pasture into a few spoonfuls of brownish liquid. The corrals are a little way out on the grassy plain, connected with the slaughtering yard by a stockade-bordered lane. The cattle are driven into these corrals or paddocks, fifty at a time, and supplied with water, but no food. Skirting the lane is a narrow platform, about the height of the animal's horns, leading down to a smaller paddock, surrounded by a similar elevated pathway, with a bridge over the opening into the galpon, which is further closed by a movable beam. Below the bridge is a low, square, iron truck on a tramway which runs into another galpon, branching into two parallel lines, so that trucks may pass one another.

Now watch closely what happens. A villainous-looking Guacho, who evidently finds pleasure in his work, mounts the stockage and takes unerring aim with his lasso at the biggest and most powerful ox. One end of the lasso is attached to a winch, turned by steam, which hauls the astonished beast, slipping and stumbling and pushing aside the other animals in his way, till his head touches the fatal beam upon which stands the matador or killer, who holds a short, broad blade, sharp-pointed knife. With one blow of this weapon, delivered close behind the horns, he severs the spinal cord, and the huge victim drops like a lump of lead, without a struggle, upon the iron truck, in waiting. The lasso is then disengaged, and the truck, propelled by two men, is pushed into an adjoining shed where one hundred men, silent but busy as bees, are skinning and cutting up carcasses.

Following the truck, we observe that one side of this great shed is lined with poles, for hanging meat upon, and the other side is occupied by a flat, slightly elevated, stone-paved place, upon which the dead cattle are laid. It reminds one of the marble slab at the morgue, and the sight of the long building, splashed with blood from end to end, the pavements running rivers of clotted gore and fifty corpses being dismembered at once by half-naked, blood-bespattered men, is ghastly, and spoils one's appetite for meat, for many and many a day.

Confining our attention to the one especial carcass, we see it hauled on to the stone-paved platform by means of a lasso attached to a horse, in position convenient for the skinner The latter worthy, a wild-looking Uruguayan spattered with gore from top to toe like an Aztec priest of the sacrifice, begins operations by cutting the animal's throat, letting loose another river of blood, so hot that it seems to steam as it seeks the gutter and emitting a sickening odor of freshness. The hide is then torn off with marvelous rapidity and—horrible to relate—the huge carcass moves and struggles, and a faint bellow is heard. No doubt the severance of the spinal cord has rendered the poor beast dead to all sense of feeling, but muscular action remains.

However, in less time than it takes to tell it, he is divided into a hundred pieces, and with lightning-like rapidity the parts are sorted and carried off in different directions. While yet warm and quivering, every particle of meat is cut from the bones, hung upon the poles that line the other side, and the skin put to soak in a bath of brine. The minutest scrap is preserved and utilized in some shape—even to the entrails, hoofs, horns and skull. The bones are ground into powder and mixed with what remains of the meat after the juice has been taken out for the extract, and, together with the blood and hide trimmings, are made into fertilizer for the soil, which is said to be better than any guano.

To return to our skinner. His knife is sharp as a razor and he uses it with incredible swiftness and dexterity. It requires just eight minutes to skin an ox and cut it into a hundred pieces, and we were informed that it can be done in five minutes. A skinner's salary is 15 cents the carcass, but if in any skin he makes the smallest hole, he forfeits payment for the animal. About thirty-five animals are said to be an average day's work, though the more expert skin fifty and upward. The men are not allowed to talk during working hours and strictest order is preserved and everything is kept as clean as the gory business will allow.

Soon as it is cooled, the meat on the poles is cleared of every particle of fat, and put to stew in large, oblong caldrons, in which the water is kept below the boiling point, for it is a peculiarity of the mixture that it contains no matter not soluble in cold water. A thin soup is thus obtained, which is carefully skimmed and strained so that the smallest trace of grease is removed. Then the soup is subjected to a series of evaporations, growing thicker and thicker, till it finally acquires about the color and consistency of sorghum; which when cool becomes a jelly and is ready for use. We are told that about one hundred oxen are killed, skinned and cut up in an hour as an average amount of work, and that in the height of the season 1,200 a day is the rule, or the neighborhood of 15,000 in seven months. Why operations are suspended for the remainder of the year I do not know.—*Commercial Bulletin.*

MINING, WASHING AND CALCINING SOUTH CAROLINA LAND PHOSPHATE.

By W. DE L. BENEDICT, E.M.

SOUTH Carolina land phosphate is found as lumps or nodules, of irregular shapes and sizes, in beds or strata of varying extents and thicknesses lying horizontally, or nearly so. It is of a grayish color, moderately hard and tough, and contains when thoroughly dried from 55 per cent. to 62 per cent. of tricalcic phosphate, or "bone phosphate," as it is usually termed. The strata average, perhaps, 9 in. in thickness, and are sometimes practically continuous for several thousands of acres in extent. They sometimes appear at the surface of the ground, and again are covered to a depth of 50 ft. or more. It is doubtful, however, if it will pay to extract the phosphate from a greater average depth than about 10 ft., unless the bed is unusually thick, or the market price for the product unusually high.

The operations of mining the phosphate and its subsequent treatment are substantially as follows (the methods about to be described being those adopted by one of the largest and most successful companies): The land is first "sounded" with a pointed steel rod to determine the depth of the stratum below the surface; then pits are dug to ascertain the thickness of the bed. The variations in the depth of the phosphate are due to the undulations in the surface rather than to any dip in the stratum. As the cost of mining is proportionate to the thickness and hardness of the "overburden," as well as to the thickness of the phosphate, and as it is desirable to keep this cost at about the same figure from year to year, it is of great importance to have an accurate survey of the property, in order that deep and shallow places may be selected to balance each other.

After suitable tracts of several acres each have been chosen, the trees are felled, the underbrush is cleared away and trenches are dug around each one in the form of a rectangle, to drain off the water to a depth greater than that of the phosphate. The land is so flat and so near the level of the river it is frequently necessary to pump the water out of the drain trenches. A railroad track is laid along the middle of the rectangular tract, and the land is then ready for the mining operations proper.

To obtain the phosphate, trenches 6 ft. wide are dug adjoining the drain trenches on the long sides of the rectangle, the earth is thrown over the drains and the phosphate is piled on the bank toward the railroad, to which it is wheeled in barrows before the next trench is commenced. The earth from the second mining trench is thrown into the space made by the first trench and the phosphate is piled on the inner bank as before and wheeled to the railroad. This is repeated till the track is reached, when that part of it which is within the limits of the rectangle is taken up, and mining is then commenced on that part which was formerly covered by the track, starting as before from the end furthest from the railroad.

The mining is divided into "tasks," each task being a space 15 ft. long and 6 ft. wide, and as deep as the phosphate stratum, which averages 5 ft. or 6 ft. Miners are paid 25 cents to 30 cents per vertical foot, according to the hardness and thickness of the overburden. For a depth of 6 ft., therefore, the pay would amount to $1.50 to $1.80 per "task" (equivalent in this instance to 15 ft. × 6 ft. × 6 ft. = 540 cu. ft., or 20 cu. yds.), or at the rate of 7½ to 9 cents per cu. yd. The miners earn from $1 to $1.25 each per day.

The stratum is made up of phosphate, more or less mixed with clay and sand, and for each foot in thickness (which is about its average thickness on this property) it will yield about 1½ tons of marketable phosphate per task; in this case equal to 15 ft. × 6 ft. × 1 ft., or 90 cu. ft. of stratum, or say 60 cu. ft. to the ton. A ton of this phosphate occupies about 24 cu. ft. so the stratum may be said to yield 40 per cent. of phosphate, or 726 tons per acre.

After this mixture is mined it is loaded into cars holding about 4 tons each, and hauled by a locomotive to the "washer." Here the cars are drawn up an incline to the top of the building, and their contents are dropped into hoppers which discharge into the crushers. The latter consist of pairs of rolls about 4 ft. long, and are set about 4 in. apart. The object of these crushers is simply to break up the larger masses and pieces of phosphate, so as to have nothing more than about 4 in. in diameter pass into the washers. Most of the nodules are smaller than this, but they are sometimes cemented together in larger masses, containing, also, clay and sand, which it is necessary to remove in order to keep up the grade of the phosphate.

From the crushers the material is discharged into the washers. Two kinds of washers are used, but the one called a "log washer" seems to do the cleaner work. This washer consists of an octagonal piece of wood about 27 ft. long and 15 in. in diameter, having cast iron teeth, each about 9 in. high by 5 in. wide, bolted to four of the eight sides in the form of a broken helix. This "log" revolves in a trough, and both are slightly inclined, so that the phosphate is "screwed" up against a current of water, which cleanses it from the sand and clay. The material to be washed is fed in at the lower end and water is discharged into the trough at various places, a strong stream being directed against the phosphate near the point of discharge to give it a final washing. The cleaned phosphate falls on an inclined screen of cast iron, having square perforations ¾ in. in diameter; all that passes through this falls on a second screen with meshes ¼ in. in diameter, and that which passes through this screen—a very small proportion—contains so much sand that it is wheeled away as "waste."

The water from the washers carries off the finer sand and clay and deposits them on the mud flats of the river, on the bank of which the washer building is placed. The other kind of washer consists of a boiler iron cylinder slightly inclined (or, sometimes, a truncated cone), having teeth similar to those just described bolted to the inside of the shell in the form of a broken helix. As the cylinder revolves, the material to be washed is forced up against a down-flowing current of water, as before. This style of washer is said to do more work than the other, but the product is perhaps not so thoroughly cleaned.

The phosphate is now ready for calcination. This is effected in kilns which consist simply of rectangular brick structures, each about 100 ft. long by 40 ft. wide. The floor is of brick also, and in it flues are arranged about 5 ft. apart and running parallel to the shorter sides, to supply the air for the combustion of the wood. The walls are about 10 ft. high and are braced on the outside with wooden buckstays. A roof of wood covers the kiln. Each kiln holds 1,000 to 1,200 tons of phosphate and 35 to 40 cords of wood are required to calcine it, or at the rate of about 30 tons per cord. The wood is piled on the bottom of the kiln and the phosphate is wheeled from the washers in barrows and dumped on the wood until the proper amount is charged, the finer phosphate being reserved to go on the top as a cover. The wood obtained in clearing the land is usually sufficient for calcining the phosphate and for fuel for the locomotives and "washers." It takes from two to five days for the fires in the kilns to burn out, and then the phosphate is ready for market.

The water in the river is deep enough for some of the smaller sailing vessels to come directly to the "washer," but when the phosphate is to be shipped in larger vessels or steamers it is loaded into lighters and towed down into deep water. The ease and simplicity with which the thickness and depth of the South Carolina deposits can be determined, and the uniform grade of the phosphate, enables one to estimate very closely the quantity of material in any given tract of land, as well as its value and the cost of mining. All of which stands out in strong contrast with the extreme irregularity of the Florida deposits of rock phosphate; which, because of their great uncertainty as to quantity and quality, require very extensive and costly development and sampling before one can even closely *approximate* their value in any considerable body of land.—*The Engineering and Mining Journal.*

CHANGEABLE PHOTO OBJECTIVES.

To make larger and smaller pictures near by and at a distance of the same length from the same standpoint, and with the same camera, several lenses were required until recently, one with very long focus, if the picture of a distant object was desired in large size, and one with short focus for near-by objects. Dr. Miethe has succeeded now in constructing an objective which is changeable, so that it will give long or short focus.

Dr. Miethe says: The size of the picture of an object on the ground glass depends upon three circumstances: First, the focal length of the objective; second, the distance of the same from the object; and, third, the size of the original. Two of these circumstances may be varied, generally the distance from the object and the focal length of the lens. If the object can be approached as desired, or if lenses can be applied of any required focal length, every object can be photographed in any desirable size. But, unfortunately, this cannot always be done. The approach to an object may for many reasons be impossible or impracticable. Inscriptions and architectural details, wild animals, flying birds, ships, etc., can oftentimes not be reached by the photographer, because he has to take his views from too great a distance. In this case remains as a last possibility the application of long-focused lenses, which is again very restricted.

Suppose we had to take a view of an inscription on a rocky cliff at a height of 100 m., with the size of letters 20 cm. To avoid a bad perspective, we will have to take it at a distance of at least 250 m. from the cliff. Our distance from the inscription will then be in an air line 280 m. To make a distinct picture the letters in the same should be at least 4 mm. high. But to obtain this, as a simple calculation will show, an objective of 5·6 focal length would be required; that is, a camera with almost 18 ft. bellows. To have such a camera for outdoor photography would be rather troublesome. Such and similar cases are frequently met with in practical life by the architectural photographer on exploring expeditions, etc. Small views and subsequent enlargements will necessarily suffer, because the grain of the plate, when an enlargement is made, will be so visible that all other detail disappears. I have tried to remove these obstacles, and, just the same as many amateurs and professional photographers have done before me, have tried the application of the telescope for this purpose. The result was far from satisfactory. Aside from the circumstantial arrangements, I did not succeed in obraining one passable picture. Cameras having a telescope in place of the lens are also too bulky and top-heavy, and vibra-

tions cannot be prevented on even the most solid tripod.

Ultimately, by application of a new principle we have succeeded in surmounting the principal difficulties. I use simply a combination of a convex lens of long focal length with a concave lens of short focal length, which are connected at variable distances. Such a system has, as can easily be proved, the following properties:

First.—It depicts enlarged, reversed pictures of distant objects.

Second.—It can be used for every camera length, therefore for every desired picture size.

Third.—The pictures at a certain focal distance increase in size in proportion to the greater difference in the focal length of both lenses.

An example will explain this:

Suppose we set a convex lens of 10 cm. focus to the distance of about 15 cm. from a convex lens of 1 cm. focus, and place the same in front of our inscription at a distance of 280 m., the system will produce a picture with a camera length of 35 cm., which is just as large as that of the lens of 5·6 local length. By a small variation of the distance between both lenses larger or smaller pictures can, of course, be produced at corresponding camera length.—*Dr. H. W. Vogel, Anthony's Bulletin.*

ON ANCIENT MSS. CONCERNING THE HISTORY OF ARTILLERY AND THE MECHANIC ARTS.*

IN a preceding article we reproduced a paper presented by Mr. Berthelot to the Academy of Sciences on the interesting study made by him of some figured MSS. of the first half of the 15th century. The learned perpetual secretary of the Academy has completed this first memoir by a very extensive work published in the *Annales de Physique et de Chimie.* He reproduces in this, through photogravure, more than sixty figures. We think that we shall interest our readers if we give a few extracts from this remarkable study, which is a true revelation for the history of the sciences. We shall begin with a few figures from the Munich MS., the origin of which appears to date back to about 1430.

Here, in the first place, we have a curious side wheel boat (Fig. 1). The drawing carries the following legend: "This is a boat that sails upon smooth water, with four paddle wheels actuated by four men, two behind and two in front. This boat is capable of carrying twenty men of arms plus the four men who set it in motion. The wheels dip in the water, and each is provided with a winch that is revolved in the interior of the boat, so that one can navigate at will upon the water. The boat must be covered, so that the men cannot be seen. In front there is a beak, and on each side a secondary point and a gun. This is called a fighting vessel, and the Catalonians use it in order to be the masters of other vessels."

This subject greatly occupied the minds of the time. Roger Bacon speaks of it in vague terms. In Valturius' *De Re Militari* (1472), in the article *De Bello Navali* (CXI.), we find figures of boats with a couple of wheels,

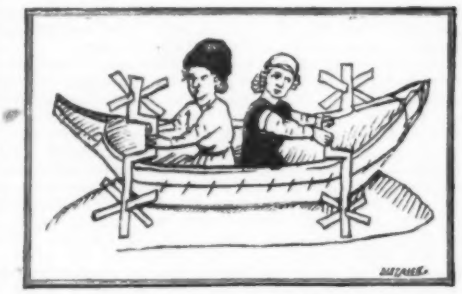


FIG. 1.—BOAT WITH PADDLE WHEELS (FIFTEENTH CENTURY).

and even with ten wheels. In the Paris MS. (7,239) there is an analogous figure. Three figures of the MS. give models of gun carriages, two of which are stationary and one upon wheels. The stock of the carriage is capable of being raised to various heights by means of a pointing arc provided with holes for pins. In the second model the gun is carried upon trunnions.

The drawings that we reproduce in Fig. 2 represent incendiary apparatus, which were already in use in the time of the crusades. Fave and Rainaud give analogous examples. The reproduction of them in the very practical manuscript book of the German engineer seems to show that they were still employed in the 15th century.

Fig. 3 represents a very curious artillery tower provided with fighting masts. Mr. Berthelot remarks that the general aspect recalls that of some of the war *materiel* of our times, such as the military tops of the armorclad ship Le Hoche.

The second book of the Latin MS. of Munich carries upon each folio a double indication. It gives figures of bombards arranged as mortars, formulas for gunpowder, guns upon carriages, hoisting machines, mechanical or military apparatus, such as capstans, screw benches, furnace bellows, wheels for raising water, models of chimneys, flying bridges, siphons for inundating enemies, pontoon bridges, etc. These figures possess a character analogous to that of the preceding drawings. We shall confine ourselves here to a mention of them.

We now come to the other Latin MS. of the same epoch to be found in the National Library of Paris, and we reproduce some of the figures that the learned chemist has especially described.

Fig. 4 represents at the upper part a bombard arranged as a mortar. The powder chamber, B, is adjusted in the center of the discharge at right angles, thus diminishing the chances of breaking the carriage. Two models are given. The carriage, A, is provided with solid wheels and a pointing rod, containing apertures for pins. Alongside of the bombard we see figured at E a scaling ladder shoved by a horse, protected by a shield fixed upon the carriage. Underneath, at F, we observe a scaling ladder carried by two men, with a mantelet in front. At the bottom of Fig. 4, we observe, at C, the carrying of a bombard over a river, and, at D, a bombard with a stock. "It sends its projectiles to a distance," says the author of the old manuscript, "because the power of the powder, being more concentrated, has more force than if it dispersed itself. In fact, this bombard has a long tube."

Fig. 5 is most interesting. It represents a boat provided with wheels. The following is the legend as formulated in the manuscript: "Man in a boat with two wheels and a cable, which draws the boat and causes the axis of the wheels to revolve. It is made to advance against the current."

Fig. 6 shows a pontoon bridge. The figure explains itself. Boards were added for the passage of the troops.

Fig. 7 shows at the upper part the carriage of firearms in a mountain pass, and at the lower part the carriage of firearms and ammunition in boats provided with wheels. These boats were capable of being taken out of the water, and the wheels with which they were provided allowed them to be hauled upon the ground by means of buffaloes.

These documents are of very great interest. They shed a new light upon the history of the mechanical and military sciences toward the end of the middle ages.—*La Nature.*

* Continued from SUPPLEMENT, No. 837, p. 13360.

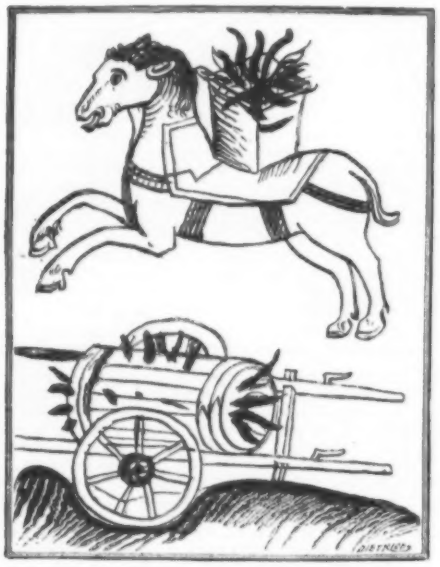


FIG. 2.—INCENDIARY APPARATUS OF FIFTEENTH CENTURY.

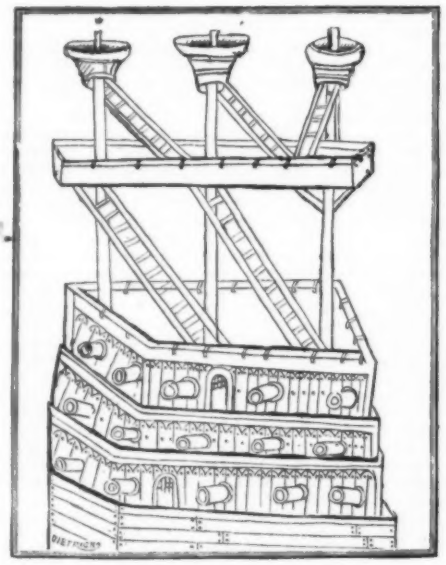


FIG. 3.—TOWER PROVIDED WITH MILITARY TOPS (FIFTEENTH CENTURY).

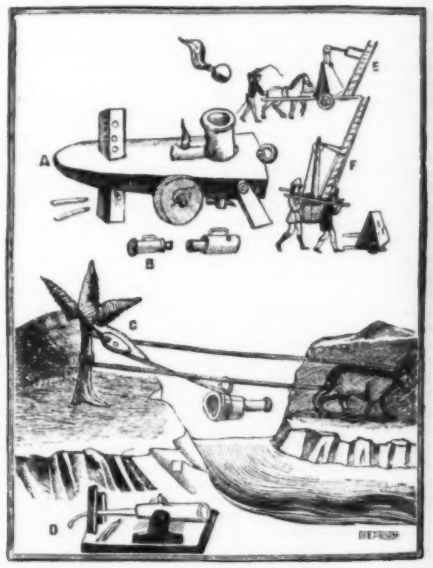


FIG. 4.—BOMBARD ARRANGED AS A MORTAR, AND CARRIAGE OF A BOMBARD ACROSS A RIVER.

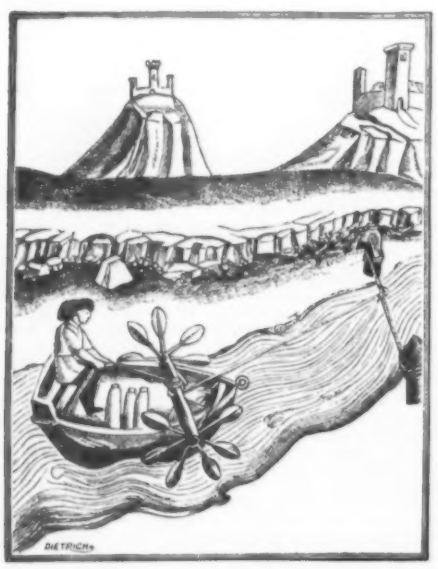


FIG. 5.—BOAT WITH SIDE WHEELS MOVED BY A FIXED CABLE.

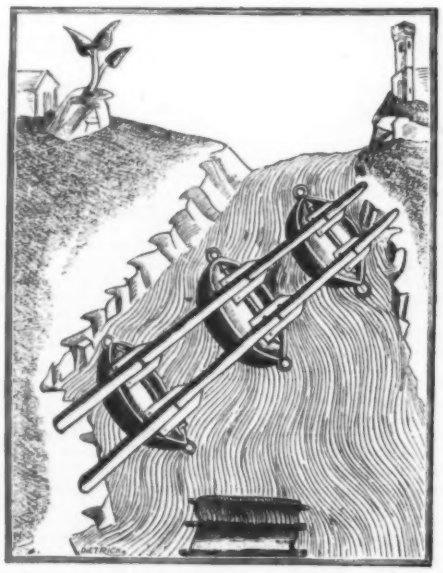


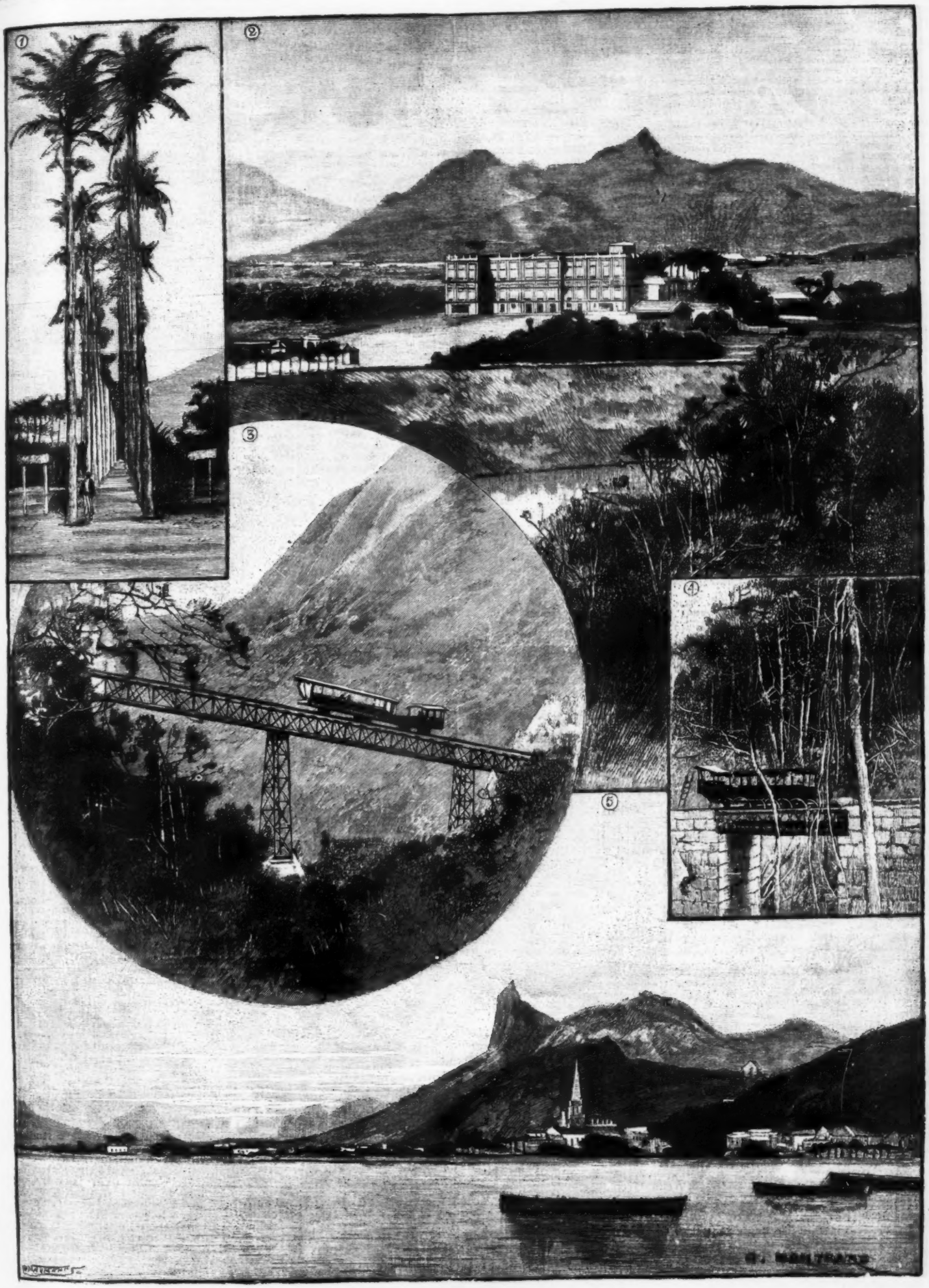
FIG. 6.—PONTOON BRIDGE OF FIFTEENTH CENTURY.

FIG. 7.—METHODS OF CARRYING FIREARMS (FIFTEENTH CENTURY).

SKETCHES IN BRAZIL.

A FEW sketches of Rio de Janeiro, the capital of Brazil, have already been furnished by our special artist, Mr. Melton Prior, but those now presented show no fresh incidents of political agitation. The Imperial Palace formerly occupied by the late Dom Pedro, in the beautiful suburb of San Christobal, and the Botanical Gardens, to which there is easy access by the Botafogo tramway, are familiar to all who have visited that city; one of the notable ornaments of those gardens is the famous avenue of tall palm trees. Excursions to neighboring places among the mountains around Rio, as well as on the seacoast, are performed with much facility by the aid of railways, tramways, and well-made roads, boldly and skillfully constructed, in some places ascending the face of steep cliffs and crossing deep ravines, as in the remarkable instance of "Sylvester's Bridge," which is laid at a declivity of 25 ft. in 100 ft. from the upper to the lower bank.

Petropolis, the late Emperor's summer palace, is situated forty miles from Rio, in the Organ Mountains, 2,600 ft. above the sea level, and is a delightful abode. Tijuca, thirteen miles from the city, with magnificent



1. Avenue of Palms, Botanical Gardens, Rio de Janeiro. 2. Imperial Palace, San Christobal, Rio de Janeiro. 3. Sylvester's Bridge. 4. Railroad from Corcovado. 5. Botafogo.

SKETCHES IN BRAZIL.

views, Juiz da Flora, Entre Rios, and the peak of Gavia or the Corcovado, overlooking the bay, are places which every traveler spending a few days at Rio will desire to see. The coffee plantations in the hill country, and the diamond mines at no great distance, may also invite a visit of inspection. The ascent of the Corcovado, to the height of 2,196 ft., is aided by a cog-wheel railway from Larangeiras. This ascent is rewarded by a grand prospect of the shores, the sea and the inland forests and mountains, with the city and its suburbs, which is, perhaps, unsurpassed in the world. —*Illustrated London News.*

THE STRUCTURE AND CHEMISTRY OF FLAMES.

PROF. A. SMITHELLS, assisted by Mr. H. Ingle, presented a communication on this subject at a session of the English Chemical Society. A *resume* of the paper is appended.

The authors have been engaged for a twelvemonth in investigating the chemistry of flames produced by burning known hydrocarbons; and the publication of their results in the present form is consequent upon the appearance of a paper by Herr N. Teclu in the *Journ. Prakt. Chemie* (vol. xliv., p. 246), who describes the phenomenon which served as a starting point in the author's inquiry. If a long glass tube be fitted, by means of a cork, over the metal tube of a Bunsen burner, so as to form a wider continuation of it, the flame can be caused to burn at the top of the glass tube. When the gas is turned off slowly, the flame becomes smaller, and develops a sharply defined inner cone of a greenish color, which ultimately becomes almost a flat disk of flame, and enters the glass tube. As a rule, it will descend at a rapid rate for some distance, then begin to oscillate, and finally either detonate and light the gas at the bottom of the metal tube or else go out. If the gas supply be very carefully regulated, the flame may be brought into such a state that it will descend the tube for a short distance, and then reascend; and in this condition it is very easy to see that, while the lower cone is moving, there remains at the top of the tube a steady cone of flame of a pale lilac color. By heating the glass tube at one point, so as to increase there the rate of inflammation, it is possible to fix the oscillating inner cone—that is, to prevent its reascent. It is also possible to effect this by narrowing the bore of the glass tube at one point, so as to diminish the rate of inflammation—*i. e.*, to prevent the descent of the inner cone past that point. In this way it is practicable to separate the two hollow cones of combustion which constitute the Bunsen flame, and to keep them any distance apart for any length of time. This permits of the aspiration of the gases from the space between the cones without any chance of admixture of outside air, or of products of combustion from the upper cone.

The apparatus used by the authors in most of their experiments consists of two glass tubes, one of which slides very easily within the other. The inner tube, which is the longer one, is united to the outer one by an India-rubber collar, through which it slides freely; and the two tubes are kept co-axial by a ring of asbestos packing. The projecting end of the inner tube may be fitted to a Bunsen burner; but the authors have usually led separate supplies of gas and air into the apparatus by a T tube, instead of using a Bunsen burner, in order to have a better control of the flame. With this apparatus a non-luminous flame is easily obtained; and the two cones can be separated in two ways. If the apparatus is arranged so that the flame is formed at the orifice of the wider tube, and the orifice of the narrow one is 8 or 10 centimeters below it, on increasing the air supply the inner cone of flame will ultimately descend and rest upon the orifice of the inner tube. If, on the other hand, the inner tube be made to project beyond the outer one, and the non-luminous flame be formed on it, then, if there be a sufficient air supply, on sliding up the outer tube, it will, as it passes the flame, cleanly detach and carry up the outer cone, leaving the inner one still burning on the inner tube.

The authors have made similar experiments with flames of liquid hydrocarbons by charging air with the vapor of the liquid by passing it through a "saturator," such as is used for producing the ether-oxygen lime light. The vapor-charged air is afterward mixed with more air; and, by suitably regulating the proportions, a non-luminous flame is obtained, and divided into two cones. In the case of liquid hydrocarbons, the lower cone of flame usually appears to be divided by dark spaces into several petal-like divisions, which are in rapid rotation. In the case of benzine vapor, the following sequence of appearances is presented: Starting with the orifice of the inner tube 8 or 10 centimeters below that of the outer one, a luminous, smoky flame is first obtained at the latter. As air is gradually added, the flame becomes less and less luminous, and an inner cone begins to develop; but before this has become non-luminous, it descends to the inner tube. More air makes both it and the other cone non-luminous; and this state may be maintained. If now somewhat less air is supplied, a luminous streak appears at the tip of the inner cone, and passes right up and through the tip of the upper cone. If more air is supplied, the upper cone of the flame begins to disappear, and only the upper part of it remains. This also gradually fades away, and then there is only the lower cone left. Still more air produces a visible effect on the inner cone; the color changing and the combustion becoming less intense, until the cone rises from its seat, passes upward and disappears. There is thus a gradual transition from the richly luminous flame to one consisting of a simple pale blue cone just on the point of extinction through excess of air.

The hydrocarbons examined by the authors were ethylene, methane, pentane, heptane and benzine. Coal gas was also used. The gases from the regions between the two cones of flame were analyzed in all cases volumetrically or gravimetrically. The results obtained (which were tabulated by the authors) show that the products of combustion of the first cone are essentially CO_2, H_2O, CO, and H_2; and that the second cone is due to the combustion of the CO and H_2 with the external air. The results are in harmony with the conclusions of Blochmann, obtained indirectly, and with the not generally known work of Dalton on the explosion of methane and ethylene with oxygen in quantities insufficient for complete combustion, which was repeated in 1861 by Kersten.

The authors point out: (1) That carbon, according to Baker's experiments, even in excess of oxygen, burns preferentially to CO, and not to CO_2; (2) that the heat of combustion of gaseous carbon to CO is probably greater than that of hydrogen to H_2O; (3) that, according to Dalton, CH_4, when burnt with its own volume of oxygen, gives products represented in the equation—

$$CH_4 + O_2 = CO + H_2O + H_2;$$

and they conclude that this equation represents the character of the change first taking place in the inner cone. But as the two substances CO and H_2O act upon one another, the case is one of reversible change, and four products will result, viz., CO_2, H_2O, CO, and H_2.

The conditions of equilibrium of this system, according to Dixon, are expressed by the coefficient—

$$(CO \times H_2O) \div (CO_2 \times H_2)\ 4.$$

This is subject to certain conditions of temperature and dilution. The authors in their most reliable experiments—viz., the gravimetric ones—with ethylene and coal gas, get numbers not greatly differing from 4; but they are still engaged in studying this question.

The authors have succeeded in dividing into two cones flames produced by the admixture of air with cyanogen, sulphureted hydrogen, carbon bisulphide, and decomposed ammonia—*i. e.*, $N_2 + 3\,H_2$. The products of the inner cone in the case of cyanogen were found in one experiment to consist of carbon monoxide and carbon dioxide, in the proportion of two volumes of the former to one volume of the latter.

Professor Smithells is continuing the experiments with a view of elucidating the following points: (1) The influence of differences of diameter of the tubes and rates of efflux on the fractional combustion. (2) The exact composition of the interconal gases in the case of hydrocarbons, and also of mixtures of $CO + H_2$, so as to ascertain if and in what way the above coefficient varies with the composition of the gases and other conditions. (3) The composition of the interconal gases from hydrocarbon flames while carbon is being liberated, so as to ascertain whether the luminosity of flame is due to simple decomposition of hydrocarbons by heat, to preferential combustion of hydrogen, to partial decomposition, or to other change. (4) The exact nature of the flame of cyanogen, so as to ascertain what governs the proportions of carbon monoxide and carbon dioxide formed in the inner cone. (5) The manner in which the partition of oxygen takes place in the inner cone between hydrogen and sulphur, and carbon and sulphur, and so as to obtain information as to the affinities of carbon, hydrogen and sulphur for oxygen. (6) The spectroscopic appearances of the flames.

[Professor Smithells subsequently adverted to the topic, an abstract of his remarks being as follows:]

He began by giving a brief summary of the various views that have been held on the subject. With one or two exceptions, there has been general agreement, since the time of Berzelius, that an ordinary candle flame, or the flame of coal gas escaping from a circular hole, is divisible into four chief regions: (1) The dark inner part; (2) the luminous part; (3) a small bright blue part at the base of the flame, thinning off rapidly as it extends upward; and (4) a dim, scarcely visible, faintly luminous mantle surrounding the whole flame.

The explanation which the author would give of these regions is as follows: The gas or vaporized wax, on issuing from the orifice or wick, becomes mixed with air and burns. Whether or not the flame is luminous depends on the rate at which the combustible is supplied. If slowly, sufficient air is admixed with the gas for non-luminous combustion. Thus a very small gas flame is non-luminous; and so also is the flame of a candle with the wick cropped close to the wax. It is conventionally said that coal gas burns with a luminous flame. It is just as true to say that it burns with a non-luminous flame. The small non-luminous flame of coal gas, or of a short wick candle, is seen to have the same structure as a Bunsen burner—viz., a bright blue inner cone, and a pale lilac cone superposed upon it. The author supposes that we have here the same chemical changes occurring as are dealt with in the previous paper—viz., that the first combustion in the inner cone is mainly to CO_2, H_2O, CO, and H_2; and the final one in the outer cone is mainly that of CO and H_2 to CO_2 and H_2O. This is made more probable by the fact that, if the gas supply be increased, the luminous tip shows just at the point where it appears in the experiment with benzine; and that, even after it is considerably developed, the shape of the flame betrays the persistence of the inner cone. As the gas supply is further increased, the luminous area becomes increasingly great, the relics of the two original cones being very small.

The author's view is further enforced by the simple experiment of taking a flame about five centimeters high from a Bunsen burner with the air holes stopped, noting the blue region at the base of the flame, and the dim mantle outside it, and then slowly turning on the air. The gradual transition shows unmistakably that the blue part and the mantle are the "rudiments" of the two cones of a Bunsen flame.

With regard to the luminous part, everything goes to show that it is mainly a region where hydrocarbons are decomposed by the heat of the outer parts of the flame; and the precise nature of the change is being studied by the author. The dark inner cone contains mainly unburned gas, mixed with some products of combustion from surrounding regions.

A commonly held view, that the mantle of a luminous flame is due to heated air and products of combustion, is inconsistent with the above explanation, and also with the fact that, in recent experiments, it has been found impossible to render air luminous at the highest attainable temperatures.

The view that carbon is separated in a flame owing to the preferential combination of oxygen with hydrogen is opposed, the author thinks, to all experimental evidence, which he is of opinion goes to show that, if the oxygen supply be limited, carbon will burn before hydrogen.

The author would describe a luminous flame as follows: (1) An outer sheath or mantle, with (2) an inner bright blue portion visible at the base of the flame. These two parts correspond respectively to the outer and inner flame cones of a Bunsen flame, and mark the region where the coal gas or candle gas is burning with a large quantity of air. (3) The yellow luminous part, marking the region where the heat of the parts 1 and 2 is decomposing hydrocarbons, setting free carbon, which rapidly glows and burns. (4) The dark inner region, consisting of unburned gas, mixed with products of combustion of the surrounding parts.

Novelty is not claimed for the foregoing description; but the author considers that the experiments described in the preceding paper put the matter in a somewhat new light.

THE CHEMICAL ELEMENT CARBON.

By VAUGHAN CORNISH, B.Sc., F.C.S.

THE older conception of a chemical element was that of a property, or plexus of properties, which, being common to several substances, was regarded as a *principle* existing in all those substances. In some of these old *principles* we can recognize the present chemical elements. But whereas we now think of the elements as the undecomposed residues of natural substances and as being forms of ponderable matter essentially uncreatable and indestructible, the earlier conception of a chemical principle was that of a constant *property* possessed by certain forms of matter, *e. g.*, the combustibility which is a property common to all substances of animal and vegetable growth. It is the dependence of certain properties on the presence of certain kinds of material substance which aids us in many cases to connect the older chemistry with that of the present time, by identifying some of the so-called *principles* of the seventeenth century with the corresponding *elements* of the nineteenth century chemists.

A short history of the study of carbon will serve to show the gradual evolution of certain important modern ideas with regard to chemical elements.

When vegetable or animal materials are heated with a limited access of air the result is that they are charred. Materials differing in almost every respect, except in their being formed in the processes of animal or plant life, agree in this—that when treated as above described they yield a *char*. The word *carbo*, formed from the same root, appears to have been used in the Augustan age in the same sense, namely, to designate the char left by the partial burning of animal and vegetable bodies. It was usually applied to the char obtained from wood or wood charcoal. In the more modern use of the Latin tongue *carbo* generally means coal, the vegetable origin of which is readily recognized.

The first important generalization in the history of chemistry is that contained in the theory of phlogiston, which retained its hold upon the minds of chemists till the later years of the eighteenth century. The merit of this system lay in the fact that the various phenomena of oxidation were for the first time grouped together and referred to the same agency.

The change of properties undergone by metals on calcination was a favorite subject of study with the phlogistic chemists. An equal share of their attention was devoted to the means of restoring to calxes (or oxides) the metallic properties. The phlogistic chemists recognized that the process of calcination of metals was essentially a process of burning. Now the char or substance left by the partial burning of animal and vegetable bodies constitutes the most generally applicable material for the preparation of the metals from their ores, or from the calxes. The calx or ore is mixed with charcoal, or with the analogous material coal, and these being heated together, the charcoal or coal is consumed, to all appearance ceases to exist, and a metal is produced from the calx.

It is to be observed that these changes only take place at a high temperature, and that the materials must therefore be heated. Now the primitive method of heating is to kindle a mass of vegetable matter such as wood, burning the material with a free supply of air. It was, however, found that for metallurgical operations it was more advantageous to employ the prepared material charcoal, instead of the crude material wood. In metallurgical operations the charcoal (or the analogous material coal) plays two parts, each of which is essential to the reduction of the ore or calx. The first of these functions is the production of a high temperature, the second that of acting on the heated ore so as to form a metallic substance. The charcoal employed as fuel has undergone combustion, and the charcoal mixed with the ore has apparently imparted to the ore the power of burning, that is to say, has formed from it a metal which is a material capable of burning. Coal, coke, wood charcoal, animal charcoal, lampblack—in short, all the various forms of char—appeared to possess in an eminent degree what was termed the "principle of combustibility." The word *carbone* was employed to denote the combustible *principle* contained in the various forms of char. The principle thus named is represented in terms of our modern views by what is known as a chemical element, and to this element the name *carbon* is given.

The phlogistic chemists made no real advance toward explaining the reducing action of the various bodies containing the principle or substance carbon. This explanation was reserved for Lavoisier, the great opponent of the phlogistic system. Previous to the work of Lavoisier, Black had prepared and studied the gas called "fixed air" (carbonic acid), which is obtained by the action of an acid on limestone. Lavoisier found that the same gas is formed when charcoal is burnt, and he further proved that in this process a constituent of the air (oxygen) unites with the charcoal, the fixed air or carbonic acid formed being composed of *carbon* and oxygen. Lavoisier likewise proved that in calcination the substance he termed oxygen is abstracted from the air and combines with the metal, forming a calx or oxide. Finally, he showed that if a calx be heated with charcoal in the absence of air, carbonic acid is formed, showing that the change which has taken place consists in removing the substance oxygen from its combination with the metal.

From this series of experiments it was evident that the *reducing* function of any form of char is better expressed by saying that the substance carbon removes the substance oxygen than by saying that the combustible principle carbon imparts to a calx the principle of

combustibility. These two modes of expressing the same facts may be represented thus—

Calx *minus* the substance oxygen = metal, and

Calx *plus* the principle of combustibility = metal.

From the date of Lavoisier's discovery the formation of carbonic acid has been invariably employed for detecting the presence of the element carbon. Carbonic acid gas is readily recognized even in the smallest traces by the well known property of throwing down a sediment of chalk when passed into lime water. Any substance which on burning forms carbonic acid contains, we say, the element carbon. The amount of carbonic acid formed, which can be accurately determined, supplies the best means of estimating the weight of carbon contained in any material.

If a material completely burned yields carbonic acid *and nothing else*, then we say that the material is composed wholly of the element carbon. The purest wood charcoal when completely burned yields no gas except carbonic acid, and no residue except a very small quantity of ash, in which can be recognized those mineral ingredients which the plant from which the charcoal was prepared originally derived from the soil. Wood charcoal consists, therefore, almost wholly of carbon. Any other form of char when freed as far as possible from foreign matter (*e. g.*, by drying to remove moisture) possesses the same, or nearly the same, physical constants as wood charcoal. The specific gravity is about 1·9. The materials are amorphous, or devoid of crystalline form.

It was not long after his discovery of the composition of carbonic acid that Lavoisier, in conjunction with certain other chemists, experimented on the combustion of the diamond. The diamond was placed in a glass vessel containing air, and the rays of the sun were concentrated to a focus on the diamond by means of a powerful lens. The diamond was by this means heated sufficiently to burn in the air of the vessel, and the gas evolved was collected over mercury, and tested. It was found to be carbonic acid. Soon afterward (1796) an English chemist showed that the amount of carbonic acid formed by burning equal weights of diamond and of charcoal is the same, a conclusion which has since been repeatedly verified with the superior accuracy of modern methods.

Both diamond and charcoal are therefore said to consist wholly of the element carbon.

In the year 1800, a third substance was added to the list of substances known as forms of carbon. The mineral plumbago, or graphite, was formerly regarded as identical with molybdenum (a metallic sulphide), the appearance of each being similar, and both possessing the property of marking paper with a black streak, whence the name graphite (γραφω, to write). It was shown, however, by Mackenzie, that graphite burns with formation of carbonic acid, the amount formed from a given weight of the material being the same in the case of charcoal and of diamond. Here then we have a third *form of carbon*.

These three substances differ, in the first place, in certain important physical characters. The specific gravities are different, diamond standing highest in the list and charcoal lowest. Diamond crystallizes in the regular or cubic system, graphite in the hexagonal system, while charcoal has no crystalline form or structure.

But it is not only in physical properties that the three substances differ; they differ to a certain extent also in chemical character. The temperature at which diamond burns is much higher than that at which the combustion of charcoal takes place. Thus, although oxygen unites with either substance, and in each case forms the same product, yet the readiness with which this combination takes place is very different in the two cases. In other words, the chemical relations of diamond and of charcoal, with respect to oxygen, are by no means identical. Again, graphite differs from either of the foregoing, in that the combined action of nitric acid and potassium chlorate convert it into a peculiar acid, a solid substance, known as graphitic acid.

In spite of these marked differences, chemical as well as physical, it is the universal practice to denominate all three substances, diamond, graphite, and charcoal, as "forms of the element carbon," or *allotropic* modifications of carbon. It must be confessed that the present phraseology is not as clear as might be desired, and is constantly a stumbling block in the way of the tyro in chemistry. Set a schoolboy to write an essay on "allotropy" (or the existence of elementary substances in different "forms"), and he will choose as his example the element carbon. He will begin by pointing out how widely different are the substances diamond, graphite and charcoal, and will wind up his essay by saying that, notwithstanding these differences, "they are really the same thing—carbon."

The source of confusion must be explained by reference to the atomic theory. We possess a mass of evidence to show that what we observe in any chemical process is in fact the sum total as observed on the large scale of a number of phenomena, all precisely alike, occurring between the ultimate particles or chemical atoms of the substances. All the thousands of known substances are formed by various combinations of atoms of a comparatively small number of chemical elements. All the atoms of any one chemical element are exactly alike, but are different (*e. g.* in their mass) from the atom of any other element. A substance containing more than one kind of chemical atom is termed a compound substance or chemical compound. A substance containing only one kind of chemical atom is termed an elementary substance. Such a substance is diamond; it is formed wholly from atoms of one kind, from carbon atoms. Charcoal likewise is formed wholly of carbon atoms. All carbon atoms are, we believe, alike; but this by no means necessitates the identity of substances composed wholly of those atoms. We must look upon diamond and charcoal as *structures* both formed of the same material (the carbon atom), but built up in different ways.

Regarded in this way the subject of *allotropy* is easy to understand, as easy as it is to understand, for instance, that a certain Jacobean house in Staffordshire is not a Norman castle, though built of the sandstone blocks which once formed the feudal fortress originally standing on the same site. Sandstone is the matter of which both the house and the castle have been built, and in the same way diamond, charcoal, and graphite are constructed wholly of carbon atoms; but to say simply and without qualification that diamond is carbon, and that each of the other two substances is carbon, is to employ language somewhat loosely and in a way which undoubtedly leads to confusion.—*Knowledge.*

ACTION OF THE ALKALIES AND BISULPHITE OF LIME UPON WOOD.

By Prof. ANTON IHL.

IN order to explain the chemical processes employed in the preparation of pure cellulose extracted from wood and other parts of plants, by means of non-bisulphited soda, it is necessary before all else to know the elements that compose the substance of the wood. The latter consists of nearly equal parts of cellulose and lignine. What is lignine? This question has not as yet been thoroughly answered. Singer has found in the substance of wood, vanilline, coniferine, wood resin and a substance soluble in water that is colored yellow by hydrochloric acid.

Sulphate of aniline colors wood yellow. Reaction by means of phloroglucine is still less sensitive.

Pyrrol in solution is certainly the most sensitive reagent. In 1885, the author of these lines published an article in the *Chemiker Zeitung* which showed that, in general, highly colored reactions are produced between the phenols and wood. It is particularly orcine and resorcine in alcoholic solution and in the presence of hydrochloric acid that give very sensitive reactions.

As all the reactions of wood agree neither with those of coniferine nor with those of vanilline, it must be that there are other substances in the wood that it will be necessary to look for in order to be able to explain the processes indicated above.

In his labors on the colored reactions of the essential oils, the author has found some (such as the oils of cinnamon, cloves and pepper) that give the same reactions as lignine. This is especially true as regards oil of cinnamon, which is composed of a hydrocarburet and of cinnamic aldehyde. This latter, with pyrrol, sulphate of aniline, phloroglucine, orcine, resorcine and other phenols, and with sulphuric acid, urea, lepidine and antipyrine, gives nearly the same reactions as lignine. It is therefore necessary to admit as very probable that cinnamic aldehyde is one of the elements of the substance of wood.

The fact that the urine of the herbivora contains hippuric acid in large quantity also confirms this last assertion.

The urine of the ox contains from 2·1 to 2·7 per cent. of hippuric acid when oats and wheat straw have been given it as food.

We know, too, that cinnamic acid taken internally is eliminated in the form of hippuric acid. The large quantity of hippuric acid contained in the urine of the herbivora is easily explained: the aldehyde of the incrusting substances is converted, through oxidation in the organism, into cinnamic acid and afterward into hippuric acid.

Along with the cinnamic aldehyde there may exist also a small amount of other derivatives of allylbenzol, such as eugenol, safrol, and anethol, which are very closely related to cinnamic aldehyde, and which give colored reactions analogous to those of lignine.

On considering the force of the phenolic reactions and the quantity of hippuric acid contained in the urine of the herbivora, we may admit that cinnamic aldehyde must exist in quantity in the aromatic combinations of the substance of wood. The aromatic combinations of the substance of wood are all derived from the same carburet—allylbenzol, the formula of which is:

$$C^6H^5—CH=CH—CH^3$$

Cinnamic aldehyde $=C^6H^5—CH=CH—COH$

Eugenol $=C^6H^3(OH)(OCH^3)(C^3H^5)$

Safrol $=C^6H^3(O\diagdown\diagup CH^2)(C^3H^5)$

Anethol $=C^6H^4(OCH^3)(C^3H^5)$

Coniferylic alcohol $=C^6H^3(OH)(OCH^3)(C^3H^4.—OH)$

Vanilline (a product of oxidation of eugenol) $=C^6H^3(OH)(OCH^3)(CHO)$

Another question that must be asked is how cinnamic aldehyde and the other aromatic combinations exist in lignine.

Cinnamic aldehyde does not exist in a free state in wood, for there is none eliminated by its solvents. The author of this paper has been able to dissolve only a small quantity of it by employing boiling spirit of turpentine. This solution gives colored reactions with phloroglucine and the other phenols. The other solvents have no action.

In order to answer the above question, the author made the following experiments with cinnamon.

We know that genuine oil of cinnamon is prepared by distilling the inner bark of *Cinnamomum zeylanicum* with salt water. The cinnamic aldehyde is not in a free state in cinnamon, as these experiments have proved. Extracts of cinnamon in alcohol, ether, and in spirit of turpentine and other hydrocarburets do not give the colored reactions of oil of cinnamon. Oils of cloves, pepper, and sassafras are likewise not completely formed in the constituent parts of the plants that furnish them, for the most varied extracts of these components do not show the reactions of the essential oils that correspond to them. These volatile oils are, therefore, formed on distilling the vegetable substance to which they belong with salt water. In the bark of cinnamon, the cinnamic aldehyde is probably combined with a hydrocarburet, and perhaps with another fixed substance. In the clove the eugenol is combined with a sesquiterpene, $C^{15}H^{24}$, etc. In the plants from which essential oils are extracted, combinations are probably found that behave in a manner analogous to that of the glucosides. Distilled with water, salts, alkalies, or acids, and afterward treated with ferments, these combinations are decomposed into their elements, which are, for the most part, terpenes, camphors, resins, aromatic combinations, and other substances. In lignine the conditions must be analogous. The aromatic combinations here also are combined with the terpenes, camphors, and resins, and perhaps also with cellulose, under the form of cinnamic aldehyde, eugenol, vanilline, etc. When these combinations are boiled with alkalies or acids, especially under a strong pressure, they are decomposed into their elements, as happens with the glucosides. A partial scission is produced in these combinations when wood is boiled with water. The author arranges lignine, according to its composition, with the gum resins. Under this name is comprised a mixture of gums, resins, and essential oils, and these substances are found also in lignine; but in this last the resins are found only in small quantity, while the gums predominate therein. Certain balsams and certain resins of commerce present the same colored reactions with phloroglucine and sulphate of aniline as those that are produced in lignine.

As has been seen, the gummy substances predominate in lignine; the essential constituent parts of the incrusting matters are gummides. The separation of these gummy matters will, therefore, be of great importance for the obtaining of cellulose from wood. These substances, such as we find them in wood, exhibit a great resemblance to arabine, and are found in the bisulphite process in the waste water and associated with lime, in the soda process associated with the soda, but, in this case, partially decomposed.

On carefully evaporating the lixivia of bisulphite (of pine wood) we obtain a brown, transparent, friable, viscous and resinous mass, which is nothing else than the lime salt of gummic acid—gummate of lime.

This gummy substance has, in a general way, the same properties as gum arabic. It is easily soluble in warm water and insoluble in alcohol, etc. An aqueous and concentrated solution heated with phenolic solutions and mock hydrochloric acid, or with the addition of sulphuric acid, gives colored reactions like those of the hydrocarburets mentioned by the author. It is, in particular, an alcoholic solution of phloroglucine that, heated for a long time with hydrochloric acid, acts upon gum arabic.

The acids of the gum, as we find them in wood, are soluble in warm water, and give exactly, like lime and other metallic oxides, combinations that are easily soluble in water and are precipitated therefrom by alcohol.

Along with this, the acids of the gum possess, with arabine, the property in common of being quite strong acids, for they decompose the carbonates, the sulphates and the sulphites, and that under pressure, and this explains the bisulphite process, the gummates being the substances that principally constitute lignine.

Carbonic acid does not separate the lime from aqueous solutions of the first named viscous matter. If wood is boiled with a lixivium of soda, the lignine, as has already been seen, is immediately decomposed into its elements. The gummy matters dissolve and become partially transformed. The same is the case with the resins and phenols. The volatile combinations, such as the terpenes, volatilize.

The aldehydes, such as cinnamic aldehyde and vanilline, which have the property of condensing by a secondary phenomenon, polymerize into bodies which either dissolve in a lixivium of soda or else, in case they are volatile, volatilize. Coniferine is decomposed and its two elements are dissolved. We know that sulphurous acid acts especially upon several groups of aromatic combinations by dividing them or polymerizing them. In the bisulphite process, the sulphurous acid acts, in the first place, upon the lignine, which it divides. The gummic acids set free convert, under a little higher pressure, the sulphites of lime in solution formed by the free sulphurous acid into gummates of lime, which remain in solution, and into sulphurous acid, which volatilizes.

According to the opinion of the author, it is in this fact that is found the explanation of the bisulphite process. The terpenes and the aldehydes, which condense very easily through the action of sulphurous acid, volatilize in great part as combinations polymerous with sulphurous acid. The same is the case with the other volatile combinations of the substance of wood, while the non-volatile aromatic combinations, such as the resins, remain under the form of resinate of lime.

The bisulphite process will succeed the better when there shall have been employed as much bisulphite of lime in solution as is necessary to neutralize the acids of the gum contained in the wood. If bisulphite of lime in excess has been employed, bisulphite of lime will separate upon the fiber. In case the temperature is too high there may occur a reduction of the gum by the sulphuric acid, and there will form organic acids whose lime salts are insoluble in water or which are no longer capable of decomposing the bisulphite of lime in solution.—*Moniteur Scientifique, from Chemiker Zeitung.*

CHROMOSULPHURIC ACID.

A NEW acid, chromosulphuric, possessing the composition $H_2Cr_2(SO_4)_4$, is described by M. Recoura in the current number of the *Comptes Rendus*. A short time ago the same chemist obtained a remarkable isomeric form of chromic sulphate, $Cr_2(SO_4)_3$, which exhibited neither the reactions of a sulphate nor of a salt of chromium. For instance, its solution yielded no precipitate of barium sulphate with barium chloride. This isomeric form of chromic sulphate is found to combine directly with one equivalent of sulphuric acid or of a metallic sulphate to produce the new acid, or a salt of it. Thus, when a solution of zinc sulphate is mixed with a solution of the isomeric sulphate of chromium in equivalent molecular proportion, zinc chromosulphate is formed, $ZnCr_2(SO_4)_4$. The solution of this zinc salt so obtained gives none of the reactions of sulphuric acid, nor does it yield those of chromic acid, but it exhibits the usual reactions of zinc salts; hence it must be a zinc salt of a specific acid, chromosulphuric. When the solutions of the new acid and its salts are allowed to stand, they gradually decompose, and barium chloride commences to precipitate barium sulphate. Hence they appear not to be very stable, but to decompose slowly into a mixture of ordinary chromic sul-

phate and sulphuric acid or the metallic sulphate. Boiling brings about the decomposition at once. The acid itself has been obtained in the solid state, combined with eleven molecules of water; it is a green powder, which is very hygroscopic, and rapidly deliquesces in moist air but is quite permanent in a dry atmosphere. Its solution possesses a brilliant green color when freshly prepared, but, upon standing, changes to blue, and, after a few days, passes completely into a violet-colored solution of ordinary chromic sulphate mixed with free sulphuric acid. The potassium salt has also been obtained in the solid state, combined with four molecules of water, as a green powder whose dilute solution yields no precipitate with barium chloride, but at once gives the usual potassium precipitates with platinic chloride and picric acid. This salt also appears to be formed when chrome alum is dehydrated first for some time at 90°, and finally at 110°. The sodium and ammonium salts have likewise been obtained, and are found to resemble the potassium salt closely in their nature and properties.—*Nature.*

RUSSIAN SUNFLOWER INDUSTRY.

THE sunflower, as a garden plant, has been known all over Russia for many years, but only in certain districts has it been cultivated on a large scale as an industry. The first cultivation of sunflower seed for commercial purposes began, says the United States Consul General, at St. Petersburg, in 1842, in the village of Alexeievka, in the district of Berutchinsk, government of Voronezh, by a farmer who was the first to obtain oil from the seed. This farmer soon found many followers, and the village of Alexeievka soon became the center of the new industry. The government of Voronezh is even now the chief district in European Russia for the growing of the sunflower. Besides the district of Berutchinsk, this plant is cultivated on a large scale in the districts of Novokhopersk, Ostrogoshk, Bobroosk, Valouisk, and Korotoiaks. From the government of Voronezh the cultivation of sunflowers spread to the adjacent governments of Tamboo and Saratov, where there are large fields cultivated with this plant, particularly in the latter government. The people of the province of the Don and the government of Simbersk and Samara are more or less engaged in this trade; in fact, in the entire southeast of Russia the sunflower furnishes a prominent product of the farm. Two kinds of sunflower are grown in Russia—one with small seeds, used for the production of oil, and the other with larger seeds, consumed by the people in enormous quantities as dainties. In the district where the seed is cultivated on a large scale, the plant has been continually grown on the same soil for many years in succession, thus producing a special disease of the plant. The sunflower seed is used principally for obtaining sunflower oil, which, owing to its nutritious qualities, purity, and agreeable flavor, has superseded all other vegetable oils in many parts of the country. In general, the cultivation of the sunflower in Russia is considered to be very profitable. At the average yield of 1,350 lb. to the acre, and at the average price of ½d. a pound, the farmer receives an income of about £4 an acre, and this income can be increased in those districts where the grower himself is engaged in producing the oil from the seed. The substance remaining from the oil manufacture, or sunflower cakes, being used as cattle food, is also a valuable product. These cakes, however, have a comparatively small demand in Russia, but are largely exported to foreign countries, principally to Germany and England. The government of Saratov, for instance, exports about 2,000,000 lb. of sunflower cakes to different countries, where a further quantity of oil is extracted from them before being used for cattle food. The sunflower shells, being used for heating purposes, form an article of trade in several districts. The seed cups are not wasted, but are used as food for sheep. The peasants in the government of Tambov are increasing the cultivation of the sunflower, owing to the following reasons: There is a steadily increasing demand at home and abroad for the seed, thus making the industry a profitable one, especially as Russia is the chief source of supply. As above mentioned, the sunflower is cultivated principally for the oil. If the cultivation is made with care, and if proper precautions are taken in drying, cleaning, and pressing, sunflower oil is equal to the French table oil in color, flavor, and taste.

At first sunflower oil did not meet with public favor in Russia, but later on, owing to its good qualities and cheapness, it took the place of the oil of poppy seed; but for a long time hempseed oil competed with it, owing to the fact that the lower classes, who for many years had used the hempseed oil in the preparation of various dishes, and who had long learned to relish it, were not disposed to give it up.

Now, however, public opinion has changed, and sunflower oil is preferred by the masses to all other table oils in Russia. The process of oil making is as follows:

The seed being brought to the oil mill, is thoroughly cleaned and sorted. They are passed under millstones, specially prepared for the purpose, in order to release the seed from the shells. After this the seed is properly dusted and put under a press, and, later on, into a mixer, where the seed is turned into a compact mass very much like paste, which passes into vessels heated by steam. From these vessels the paste is taken out and wrapped in a thin web, made of camel hair, and put under a press, by which the oil is squeezed out and conducted by pipes into tanks.

The total number of oil mills in Russia was, according to the last account, 104. From this number 85 were applied solely to obtaining sunflower oil. In 24 of these mills steam is used, and in others only manual power. The largest mill is at Saratov, and it produces 1,500,000 lb. of oil annually.

There are two kinds of oil obtained from the sunflower seeds. The better kind is sweet, and more expensive, the inferior having a bitter taste. The difference in the price of these two qualities is about one halfpenny a pound. The oil remaining from the oil production or the waste, and not used as food, is applied exclusively to certain industries.

The sunflower stalks, gathered from the fields, and dried in piles, have entirely replaced fire wood; in fact, these stalks are preferred even to pine wood, producing a quick and hot-flame fire. About 2,000 lb. of such fire wood are gathered from an acre of land, thus adding a great boon to a district where wood is scarce. Sunflower shells are also used for heating purposes, not only in private houses, but in large factories as well. They are burned in ovens specially prepared for their consumption. The ashes of the sunflower contain a high percentage of potassium. The experiments of Hermbstedt have proved that 1,000 lb. of dried stalks yield 57·2 pounds of ash; and from 1,000 lb. of ash are obtained 349 lb. of the best potassium. As a food for cattle, sunflower cakes are looked upon as the best in Russia; they are considered better even than hempseed or rapeseed cakes. According to chemical analyses, the sunflower cakes from the government of Saratov contain: Azotic substances, 42·31 per cent.; oil, 14·7 per cent.; and ashes, 5·12 per cent. The dried seed cups, if ground, are used in many districts as food for cattle, and particularly for sheep, with great success.

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